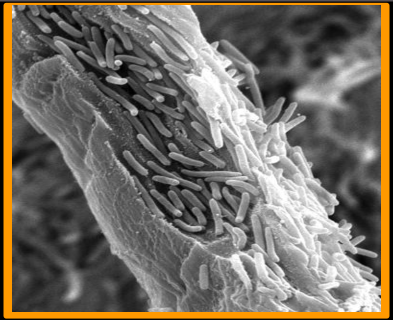


GWRDC DPI1011: Setting Benchmarks and Recommendations for Management of Soil Health in Australian Viticulture

Beechworth 18th June 2014

State Government Victoria
Department of Environment and Primary Industries
National Research FLAGSHIPS Water for a Healthy Country CSIRO
SARDI R&D South Australian Research and Development Institute
GWRDC Grape and Wine Research and Development Corporation

Project Team

DEPI Vic
Jacky Edwards
Ian Porter
Dean Harapas
Pauline Mele
Bernie Carmody
David Pearce

SARDI
Belinda Rawnsley

Consultant
Prof white

CSIRO
Rob Bramley
Danni Oliver

GWRDC
Keith Hayes (Elise Hayes)

Why is Soil Health/Quality Important to the National Agricultural Industries?


FACT SHEET 13

WATER & VINE
Managing the challenge

MODULE 13
Soil Health - what is it, how do we assess it and how do we improve it?

AUTHOR:
Jacqueline Edwards, Ian J Porter and Mark Imhof
Department of Primary Industries, Victoria

waterandvine.gwrdc.com.au

Management of soil health
for sustainable vegetable production

Horticulture Australia VG06090

- Improve profit
- Maintain or improve yields
- Improve disease control
- Improve water use efficiency
- Protect rivers and marine environments from flow of nutrients (N,P) and pesticides
- Maintain good soil structure and prevent erosion
- Maintain biodiversity
- To be good stewards of the land
- Reduce labour costs
- Reduce pesticides
- Avoid erosion
- Avoid salinity
- Improve image
- Improve wine quality?

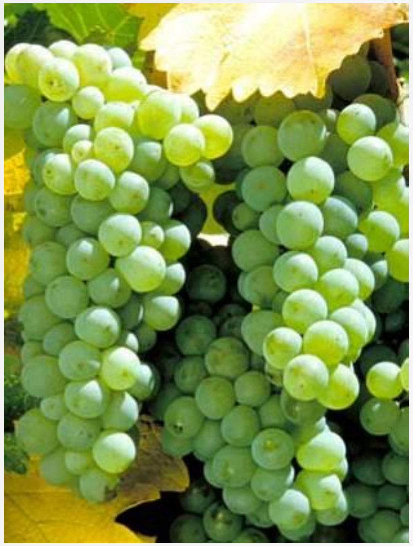
To Ensure Consistency?

Why would you want to improve soil health/quality on your property?

Key Outcome	Priority Score
Productivity, yields	3
Wine quality	3
Water Use	2
Organic Carbon	2
Soil structure	2
Education	2
Land Stewardship	1

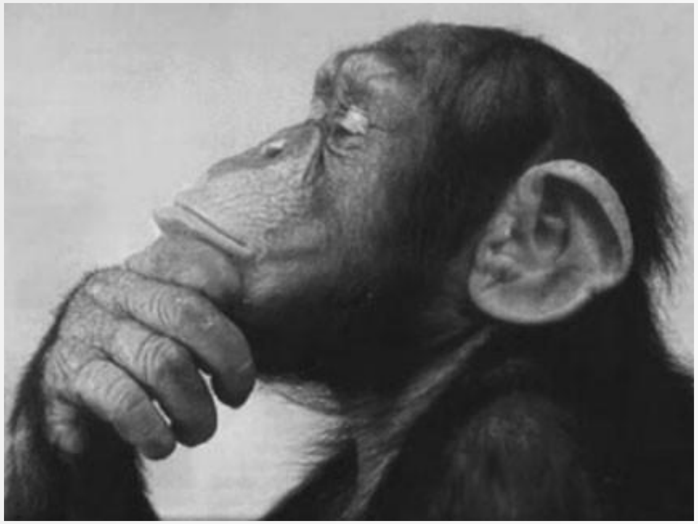
Productivity/yield

Wine quality



★★½	★★★	★★★½	★★★★	★★★★½	★★★★★	
75-79	80-83	84-86	87-89	90-93	94-97	98-100
12	14 15	15.5	16.5	17 18	19 19.5	20
NO MEDAL		BRONZE		SILVER	GOLD	GOLD

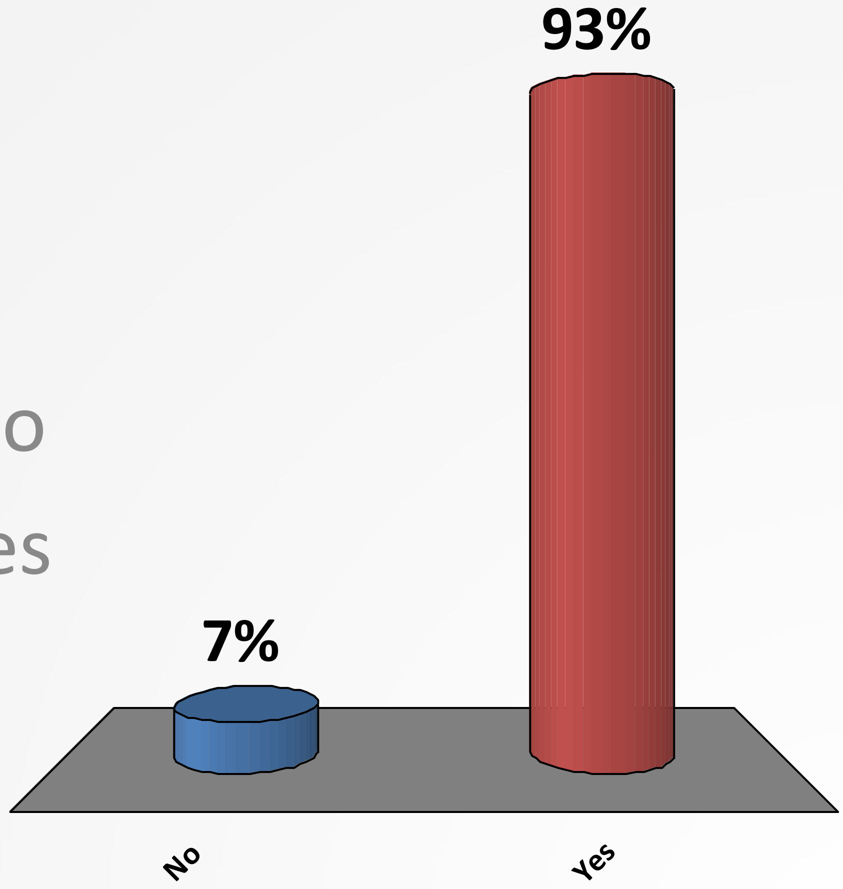
Do soil quality characteristics influence wine quality?



Do soil quality characteristics influence wine quality?

A. No

B. Yes

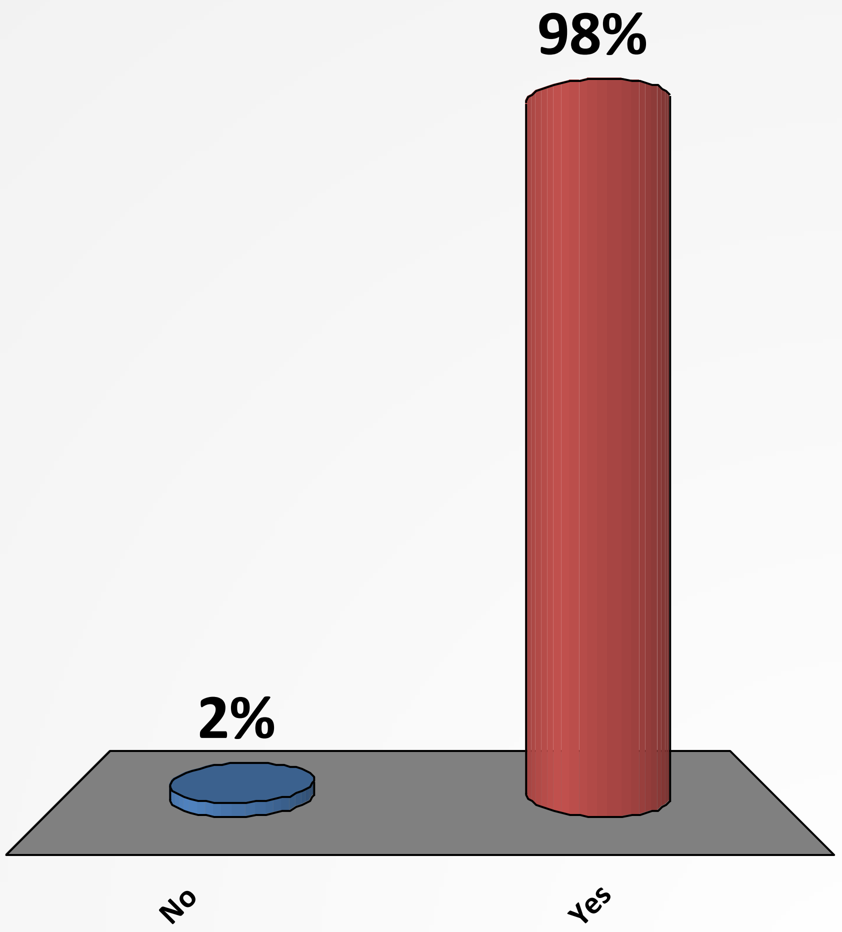


Can we change soil characteristics to improve wine quality?

Can we change soil characteristics to improve wine quality?

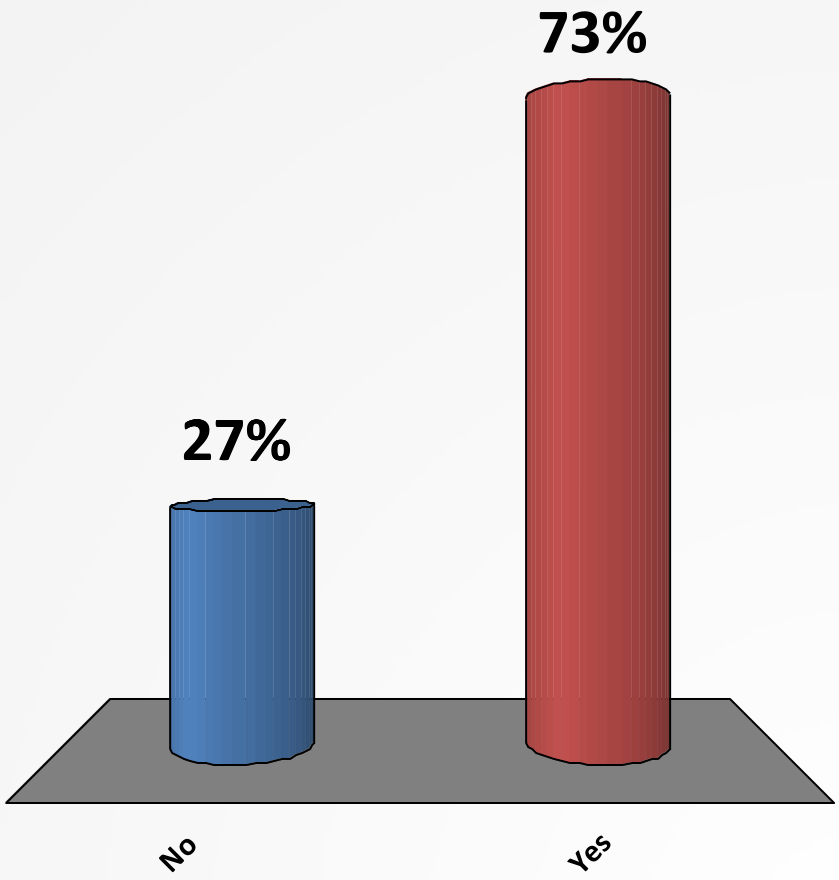
A. No

B. Yes



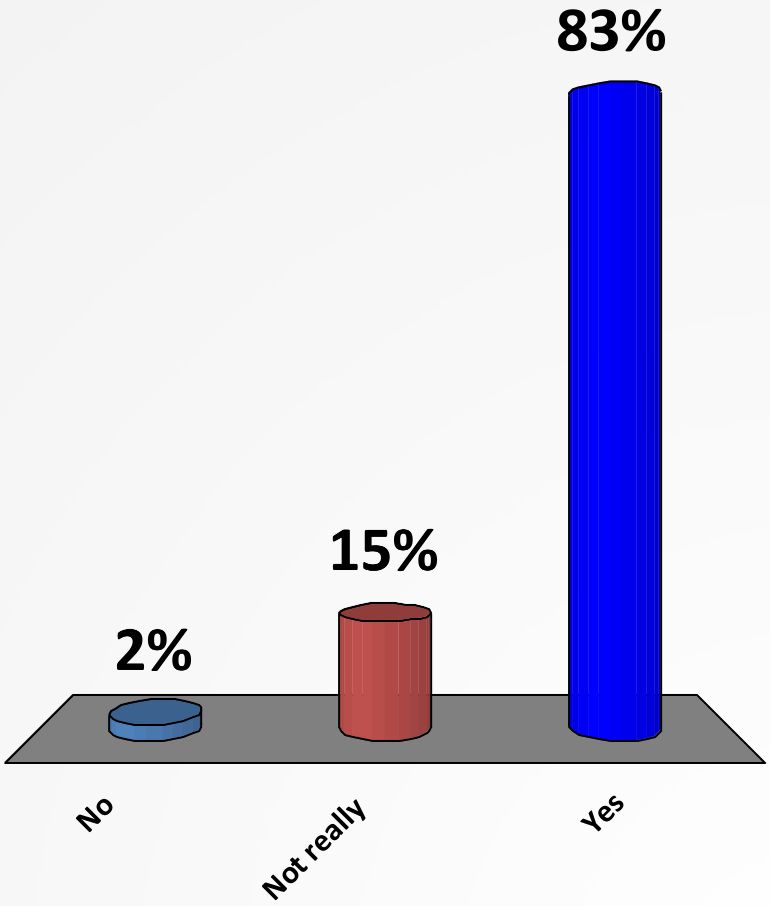
Do you Presently Use Soil Tests?

A. No
B. Yes



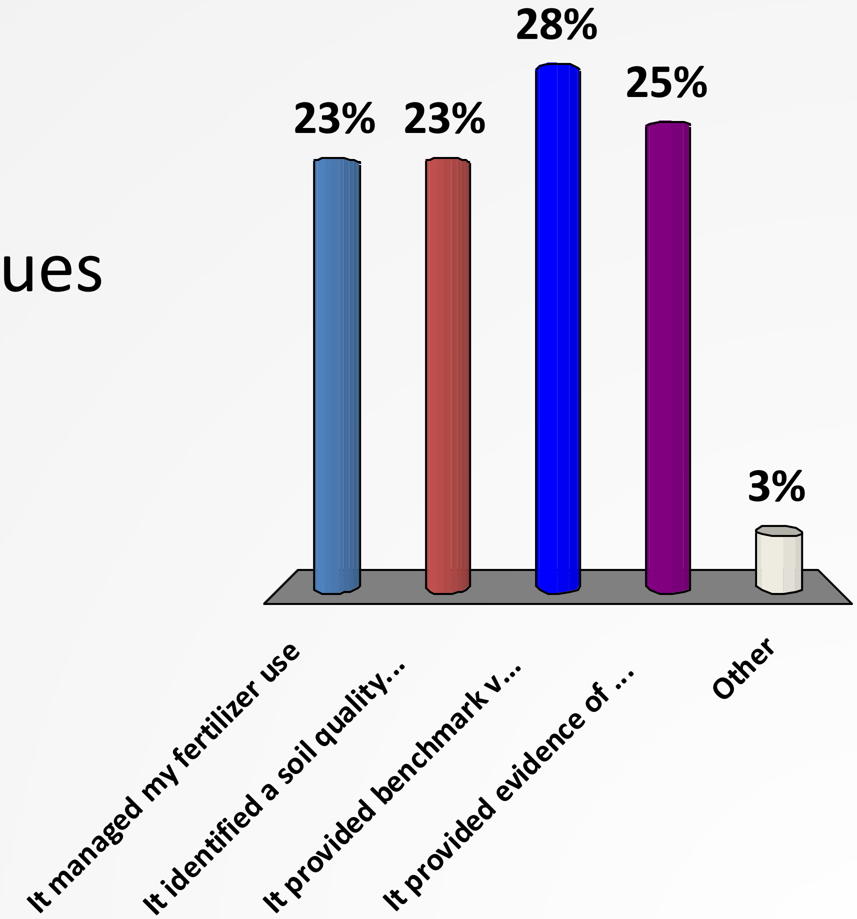
Was the Soil Test Useful?

A. No
B. Not really
C. Yes



What was Most Useful Information from the Test?

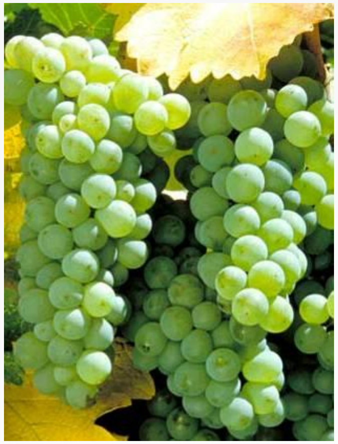
A. It managed my fertilizer use
B. It identified a soil quality constraint
C. It provided benchmark values for my property
D. It provided evidence of improvement in my soils
E. Other

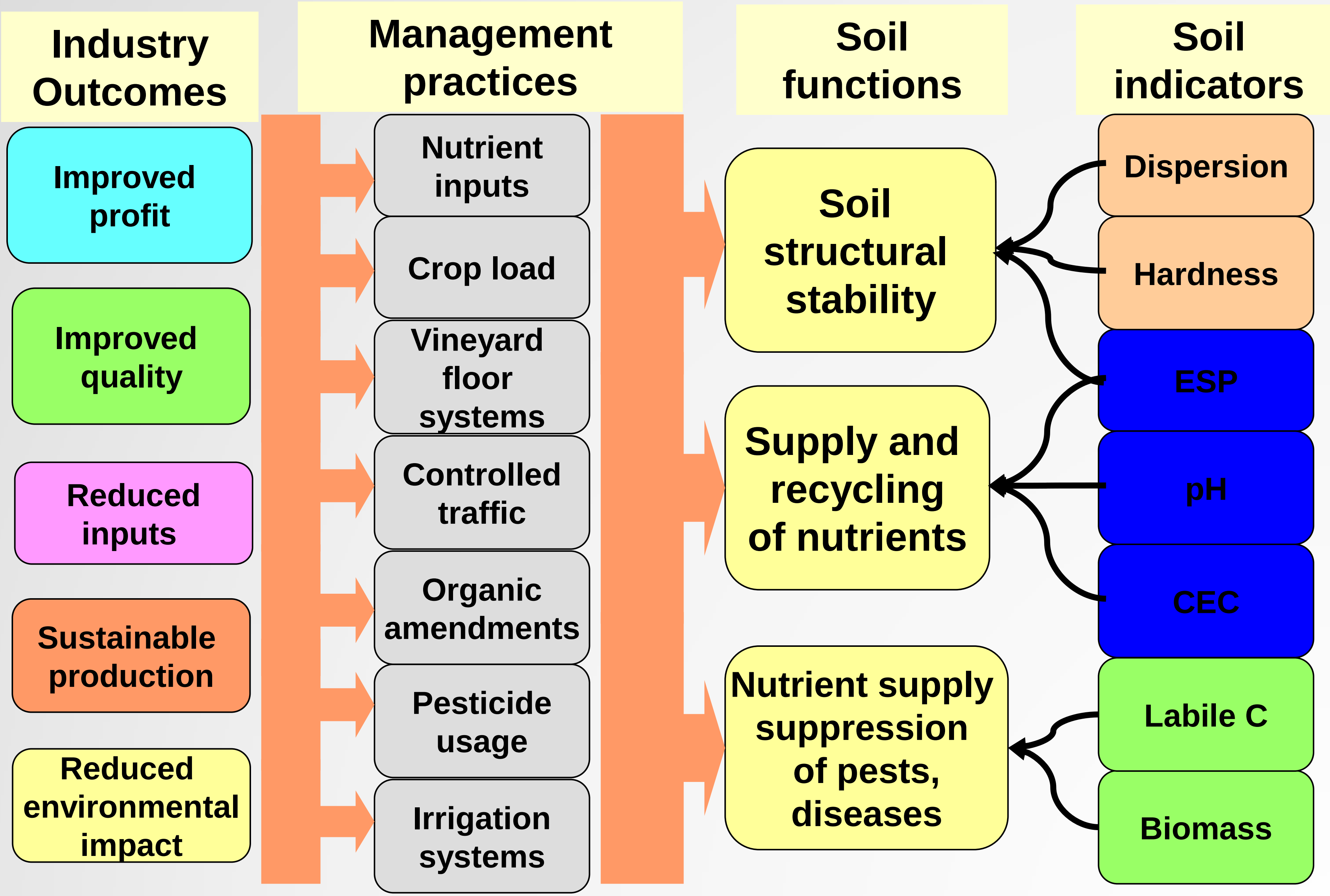


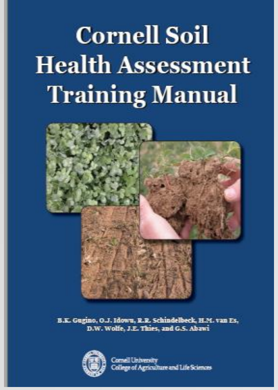
GWRDC: Setting Benchmarks and Recommendations for Management of Soil health in Australian Viticulture

Aims:

- To identify a minimum set of indicator tests to measure biological, physical and chemical changes in soil
- To benchmark different management systems and regions
- Develop fact sheets which link indicators tests, grower management and vine performance?
- Link results with grower management and Entwine requirements, etc.

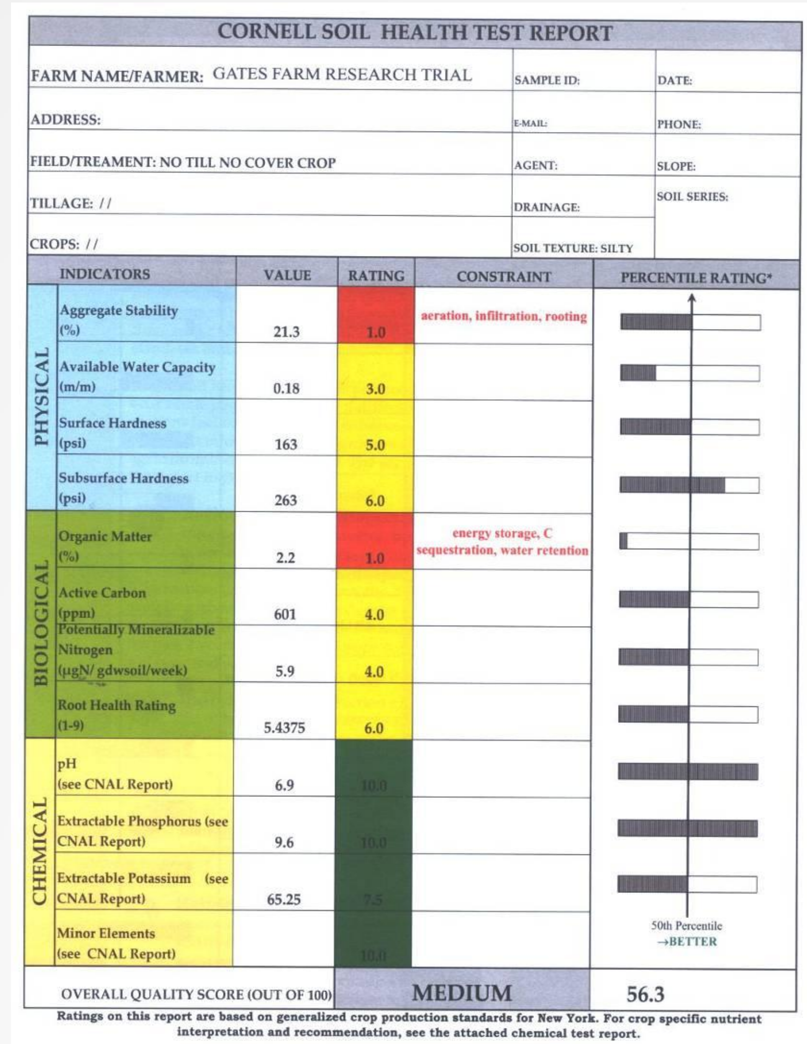



Industry Outcomes
Management practices
Soil functions
Soil indicators
Improved profit
Improved quality
Reduced inputs
Sustainable production
Reduced environmental impact
Nutrient inputs
Crop load
Vineyard floor systems
Controlled traffic
Organic amendments
Pesticide usage
Irrigation systems
Soil structural stability
Supply and recycling of nutrients
Nutrient supply suppression of pests, diseases
Dispersion
Hardness
ESP
pH
CEC
Labile C
Biomass



Cornell University Soil Health Test Report: Uses huge database to benchmark information and farms

Soil Indicator	Soil Process (Function)
Soil Texture and Stone Content	all
Aggregate Stability	aeration, infiltration, shallow rooting, crusting
Available Water Capacity	plant-available water retention
Soil Strength (penetrometer)	rooting
Organic Matter Content	energy/C storage, water and nutrient retention
Active Carbon Content	organic material to support biological functions
Potentially Mineralizable Nitrogen	ability to supply N
Root Rot Rating	soil-borne pest pressure
pH	toxicity, nutrient availability
Extractable P	P availability, environmental loss potential
Extractable K	K availability
Minor Element Contents	micronutrient availability, elemental imbalances, toxicity



CORNELL SOIL HEALTH TEST REPORT

FARM NAME/FARMER: GATES FARM RESEARCH TRIAL	SAMPLE ID:	DATE:
ADDRESS:	E-MAIL:	PHONE:
FIELD/TREAMENT: NO TILL NO COVER CROP	AGENT:	SLOPE:
TILLAGE: //	DRAINAGE:	SOIL SERIES:
CROPS: //	SOIL TEXTURE: SILTY	

	INDICATORS	VALUE	RATING	CONSTRAINT	PERCENTILE RATING*
PHYSICAL	Aggregate Stability (%)	21.3	1.0	aeration, infiltration, rooting	
PHYSICAL	Available Water Capacity (m/m)	0.18	3.0		
PHYSICAL	Surface Hardness (psi)	163	5.0		
PHYSICAL	Subsurface Hardness (psi)	263	6.0		
BIOLOGICAL	Organic Matter (%)	2.2	1.0	energy storage, C sequestration, water retention	
BIOLOGICAL	Active Carbon (ppm)	601	4.0		
BIOLOGICAL	Potentially Mineralizable Nitrogen (µgN/ gdwsoil/week)	5.9	4.0		
BIOLOGICAL	Root Health Rating (1-9)	5.4375	6.0		
CHEMICAL	pH (see CNAL Report)	6.9	10.0		
CHEMICAL	Extractable Phosphorus (see CNAL Report)	9.6	10.0		
CHEMICAL	Extractable Potassium (see CNAL Report)	65.25	7.5		
CHEMICAL	Minor Elements (see CNAL Report)		10.0		50th Percentile →BETTER
	OVERALL QUALITY SCORE (OUT OF 100)		MEDIUM		56.3

Ratings on this report are based on generalized crop production standards for New York. For crop specific nutrient interpretation and recommendation, see the attached chemical test report.

What has been done so far?

1. Two industry workshops to select a set of standardized indicators for soil quality.
2. Sampling of approx. 600 sites across 200 properties in 4 regions (McLaren Vale, Barossa, Yarra Valley and Sunraysia) – undervine, mid row and native sites, using the standardized set of indicators to determine biological, chemical and physical parameters of soil quality.
3. Development of individualized grower booklets which have benchmarked grower sites with the regional average and started identifying regional constraints.
4. Conducted two major field trials which have demonstrated the successful use of the indicator tests of soil to assist management of a constraint and the resultant benefit the industry

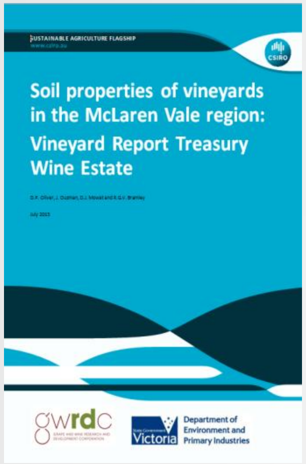
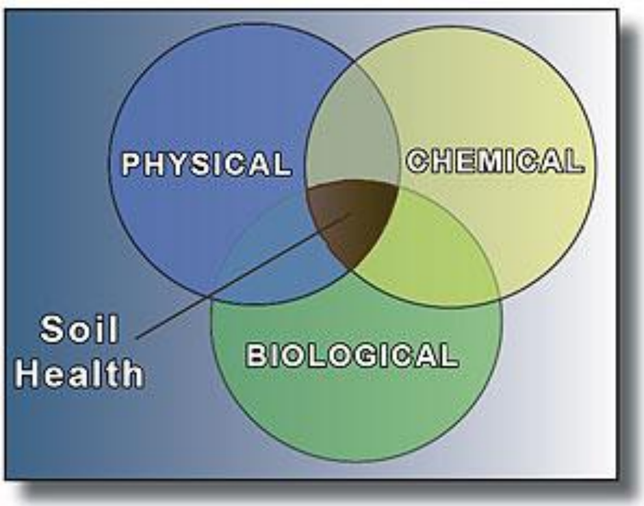


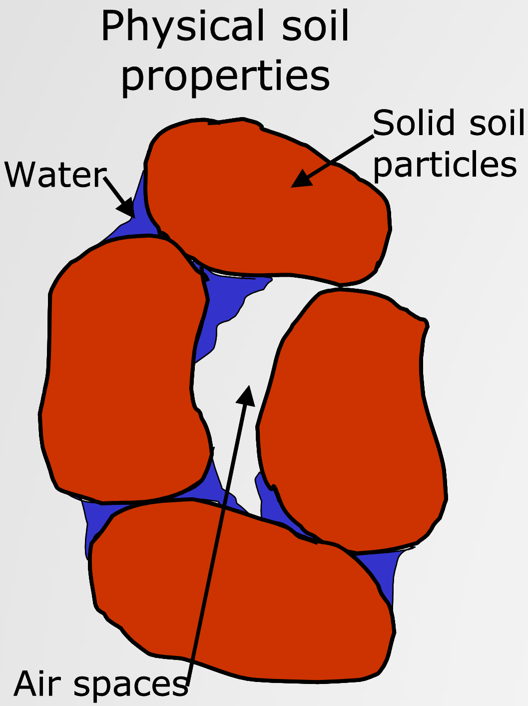
Table 3 Results of analyses in sub-surface soils (35-45 cm) for Treasury Wine Estate Winery sites and McLaren Vale average.

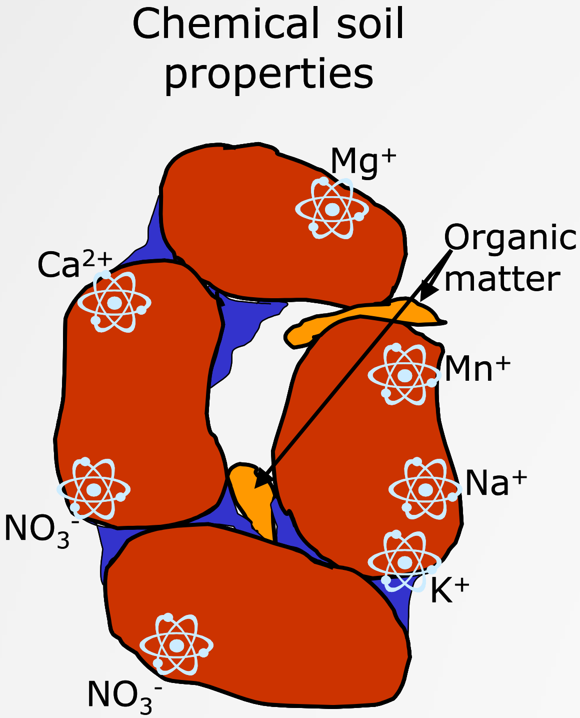
Location	Ammonium Nitrogen mg/kg	Nitrate Nitrogen mg/kg	P[1] Colwell mg/kg	K[2] Colwell mg/kg	Sulphur mg/kg	Organic Carbon %	Conduct-ivity dS/m	pH Level ($CaCl_2$)	pH Level (H_2O)	Chloride mg/kg	Exch Ca[3]	Exch K[3]	Exch Mg[3]	Exch Na[3]	CEC[4]	ESP[5]
Undervine																
Regional Average	1.23	2.53	13.7	229.1	50.43	0.68	0.27	7.1	7.9	149.4	11.9	1.15	3.46	1.22	17.8	9.78
Bethany	0.50	2.00	3.0	222.0	58.20	0.86	0.16	7.6	8.3	18.1	20.3	0.75	4.30	0.30	25.6	1.17
Booths	2.00	2.00	4.0	432.0	76.40	0.81	0.45	7.0	7.8	162.6	15.6	1.40	6.25	2.22	25.4	8.73
Midrow																
Regional Average	1.81	2.62	12.2	209.9	28.56	0.69	0.13	6.8	7.6	30.1	12.2	0.84	3.35	1.28	17.7	9.93
Bethany	2.00	4.00	4.0	258.0	23.30	1.32	0.16	7.6	8.4	20.3	26.0	1.01	5.51	0.34	32.9	1.03
Booths	3.00	4.00	6.0	435.0	7.00	0.92	0.23	6.7	7.7	4.9	17.9	1.62	6.96	0.65	27.1	2.40
Native																
Regional Average	1.14	2.86	6.0	296.1	16.68	0.84	0.27	6.9	7.8	200.9	12.1	1.30	3.06	1.23	17.7	7.60
Bethany	1.00	3.00	4.0	241.0	6.20	1.18	0.10	7.8	8.6	18.9	21.9	0.82	4.70	0.27	27.7	0.98
Booths	4.00	8.00	4.0	389.0	4.20	1.04	0.16	7.4	8.2	9.3	24.7	1.71	4.08	0.75	31.2	2.40

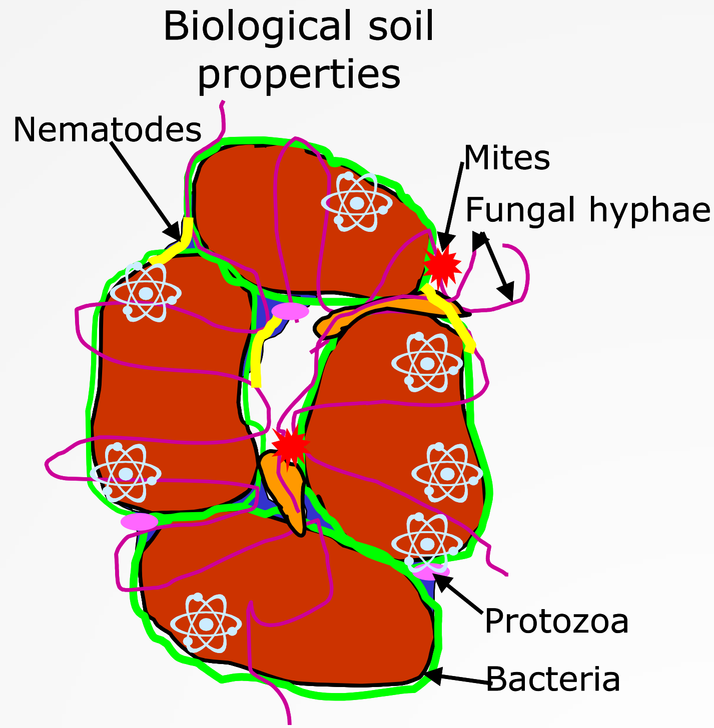
[1] P=phosphorus; [2]K=potassium; [3] Exchangeable cations determined with a pre-wash; results in meq/100g; 1 meq/100g=1cmol/kg; [4]CEC=cation exchange capacity; [5]ESP=exchangeable sodium percentage

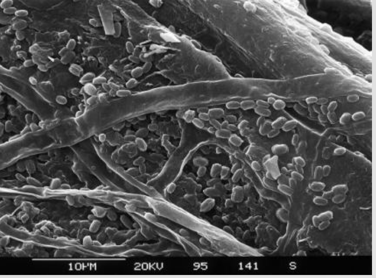
Soil properties needing tests



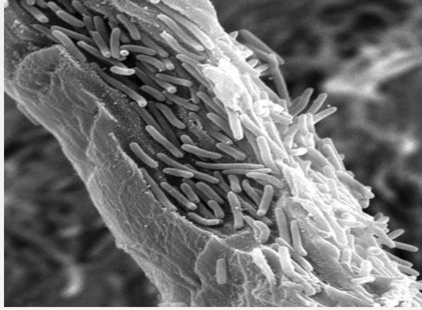








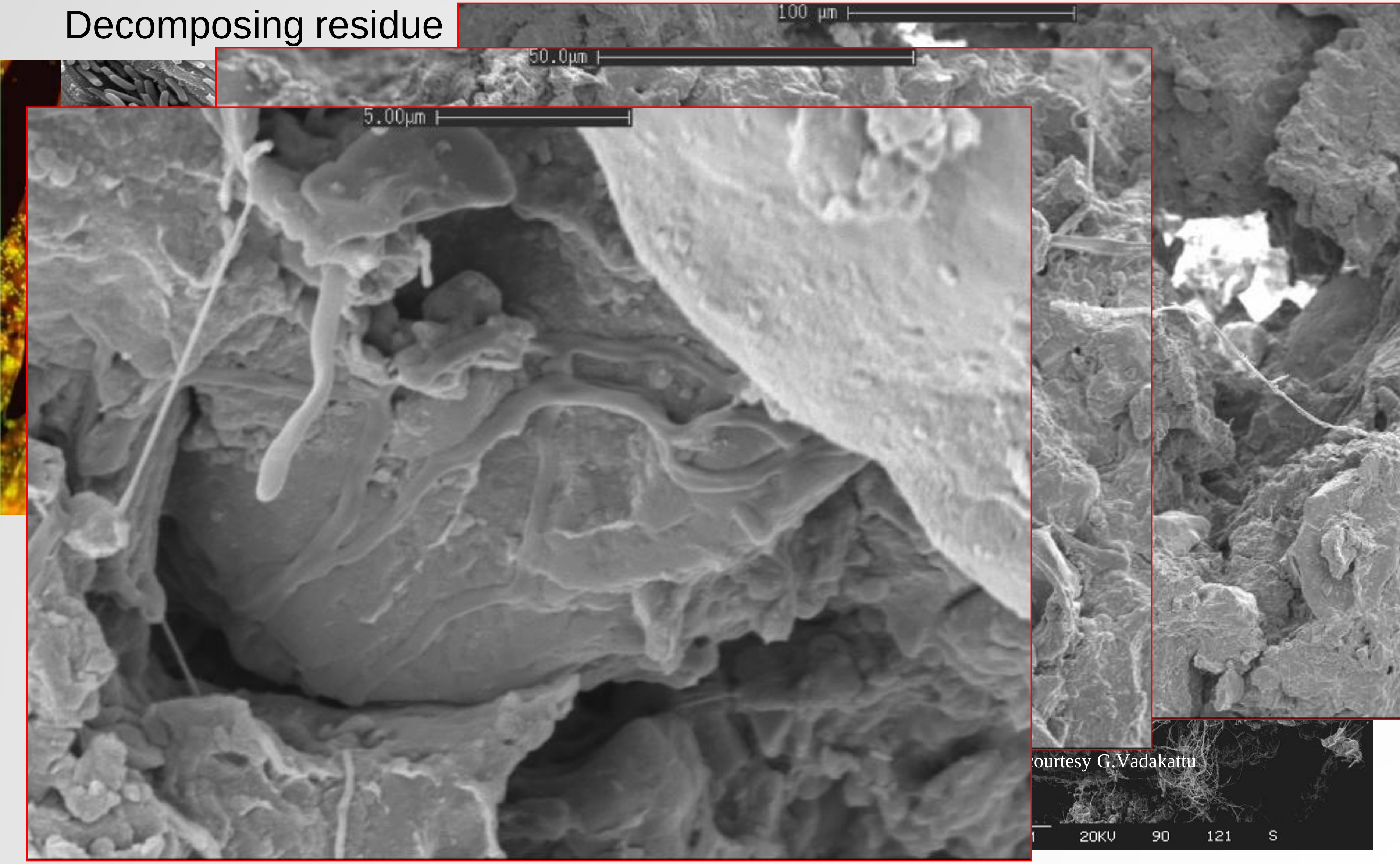
Biological indicators



- **Soil microbial biomass**:
  - living component of soil organic matter excluding roots and macrofauna
  - Measure of the microbial population density
- **Potentially mineralizable nitrogen (PMN):**
  - amount of nitrogen converted to a plant-available form by soil microbes
  - measure of soil biological activity
- **Labile Carbon/DOC:**
  - Organic matter fraction available as food source for soil microorganisms
  - Measured by colour change reaction

Importance of Biology

Decomposing residue

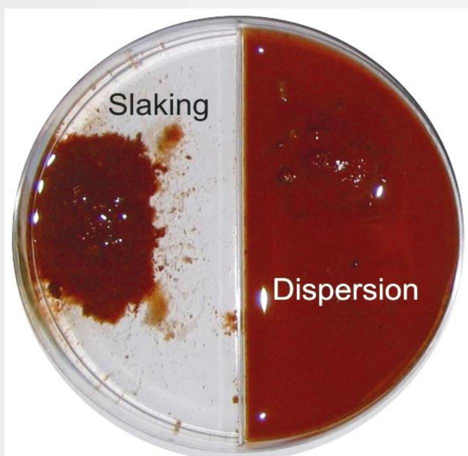


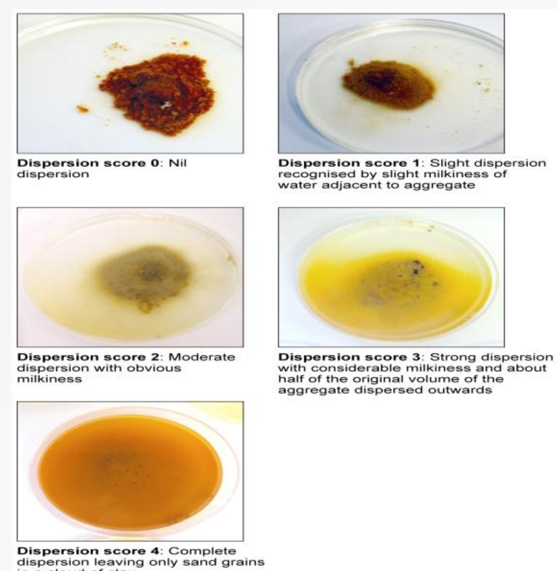
Physical indicators

1. Aggregate stability

- Aggregates (peds) may collapse (slaking/dispersion) when water is added

- Results in hard setting surface crusts and /or impermeable sub-soil layers, adversely affecting:
  - Air and water movement
  - Aeration
  - Root penetration and seedling establishment





Physical indicators

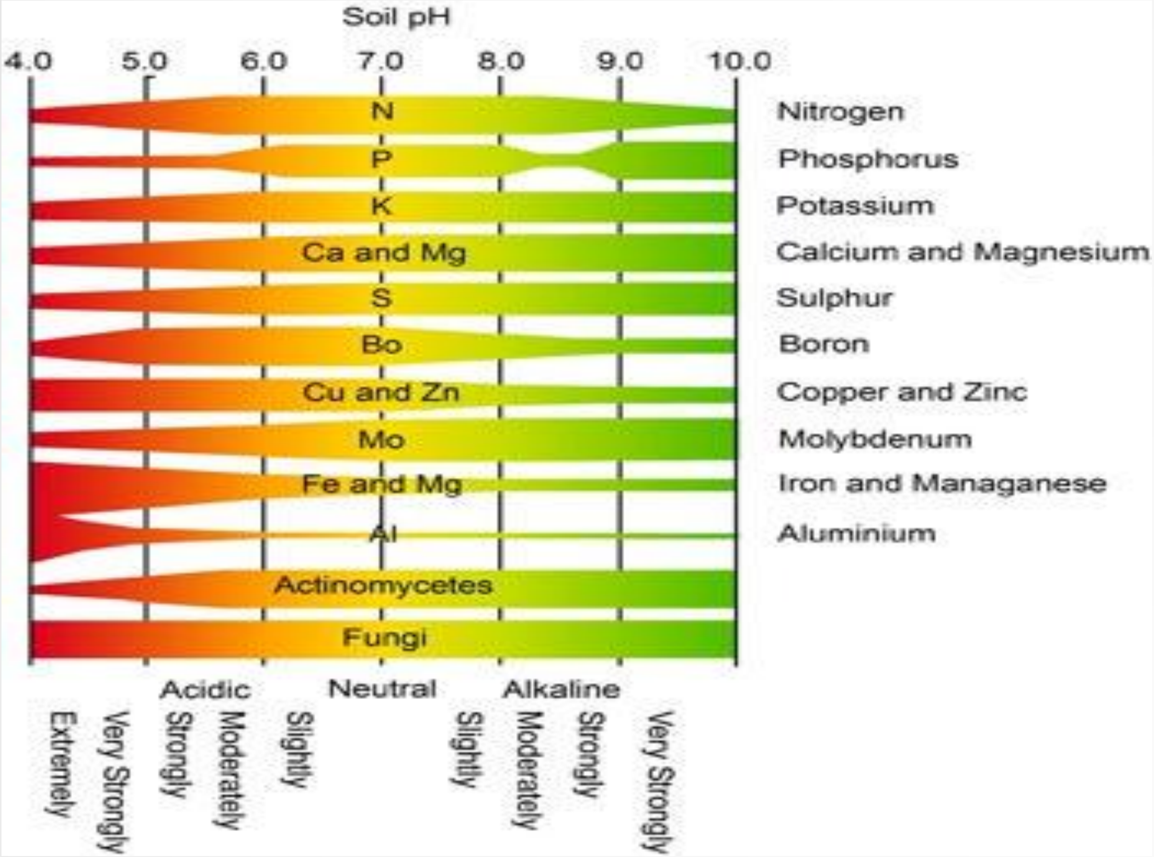
- Air Dry Consistency (ADC)
  - Measure of the strength and coherence of a soil
  - Gives an indication of root impedance, workability and permeability

Strength Class	Description
1 Loose	No force required, separate particles such as loose sands
2 Very weak	Very small force, almost nil
3 Weak	Small but significant force
4 Firm	Moderate or firm force
5 Very firm	Strong force but within the power of the thumb and forefinger
6 Strong	Beyond the power of the thumb and forefinger. Crushes underfoot on a hard flat surface with small force
7 Very strong	Crushes underfoot on a hard flat surface with full body weight applied slowly
8 Rigid	Cannot be crushed underfoot by full body weight applied slowly

Chemical indicators

- pH: pH $_{water,}$ pH_{CaCl2}

- Optimum 5.5 – 8 (water) for grapevines
- Influences nutrient availability, microbial activity



Chemical Tests

1. **Exchangeable cations Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}**

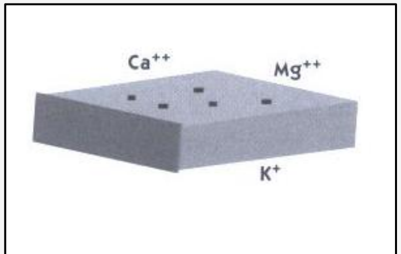
- +ve cations are held in the root zone on the -ve clay and organic matter particles (cation exchange capacity, CEC)
- CEC = major controlling agent of soil structure stability, nutrient availability, pH, buffering capacity

2. ESP – Exchangable sodium percentage

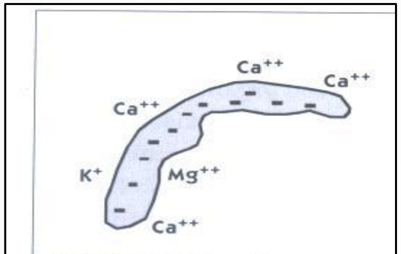
- Sodicity

3. **Total organic carbon and (Labile C, DOC)**

- Measure of total organic matter
- Important to a wide array of soil functions
- Associated with nutrients and microbes
- Increases cation exchange capacity (CEC)
- Maintains soil structure



b) cations held on clay particle



a) cations held on humus

Minimum Data Set for Industry

INDICATOR	THRESHOLD VALUES	FUNCTION/ISSUE
BIOLOGICAL		
Microbial biomass, chloroform	>300 ug/g	Soil biological activity
Potentially mineralizable nitrogen (PMN)	*8-18 mg N/g soil/week*	*N supply capacity*
Labile carbon	*> 500 ppm*	*Soil biological activity*
PHYSICAL		
Aggregate stability /dispersion (ASWAT)	Good < 6 (0-16)	Infiltration, aeration, rooting, erosion
Aggregate stability /slaking	No slaking, (0-3)	Infiltration, aeration, rooting
Air dry soil consistence (ADC)	<2	Rooting, compaction, erosion
CHEMICAL		
pH	5.5 - 8 (water)	Nutrient availability, plant growth
EC	< 1.4 dS/m	Salinity
Exchangeable cations (Ca, Mg, K, Na) Sum = effective cation exchange capacity (CEC) ESP = Na/CEC x 100%	Ca 60-80% Mg 15-50% K 1-10% Na <6%	Buffering capacity, nutrient availability Na – sodicity, dispersion, soil structure
Total organic carbon	> 2%	CEC, buffering capacity, microbe food source, energy storage, water holding capacity
Chloride	*< 175 ppm*	*Salinity*

First year… to ensure tests gave a useful outcome

Physical Parameters

Orlando						
Topsoil 0-15 cm						
		Treatment			Optimum Range (Thresholds)	Comment
Data	Units	Control	Midrow	Mulch		
Physical Parameters						
Average of ADC	Rating (0-7)	1.33	1.17	1.00	<2.00	If >2.0 add organics, gypsum several years beforehand to correct chemical imbalance, effective deep ripping and correcting the cause
Average of Slaking	Rating (0-3)	0.67	0.17	0.33	0	Sow an active fibrous crop (eg. perennial ryegrass (long lasting
Average of ASWAT	Rating (0-4)	1.67	2.00	0.89	6 or below is preferred state	Gypsum needed as you approach 6 or above

Second and third years…….

- Benchmark regions
- Conduct trials & compare paired sites
  - Constraints
- Begin industry focus groups to do their own sampling e.g. Mornington

Sampling Sites 2013 and 2014

Benchmarking 2013 &2014 at 30 sites in 4 regions
Barossa Valley; McLaren Vale, Murray Valley, Yarra Valley

Standardised methodology

- Same time, same place, same method
- Approx 4 weeks after harvest
- Undervine, mid-row, non-production
- Single panel;   near dripper, approx 20 cm from trunks; centre of midrow
- Surface: 0-15 cm, 5 pooled cores – biol, chem; undisturbed peds – phys.
- Subsurface 35-45 cm, 3 pooled cores – chem; undisturbed peds – phys.

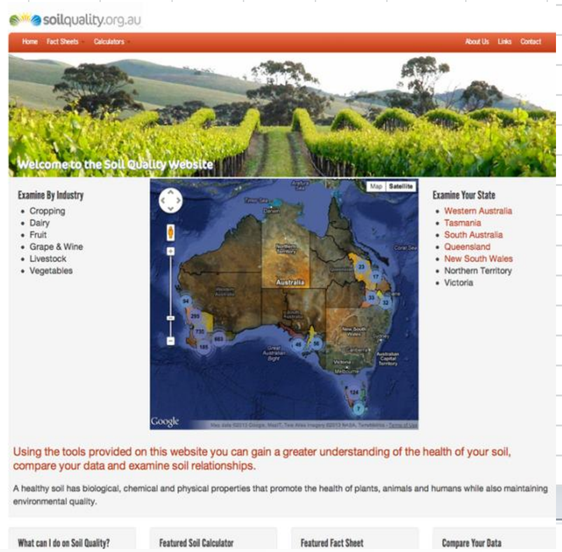

dripper
dripper
20 cm

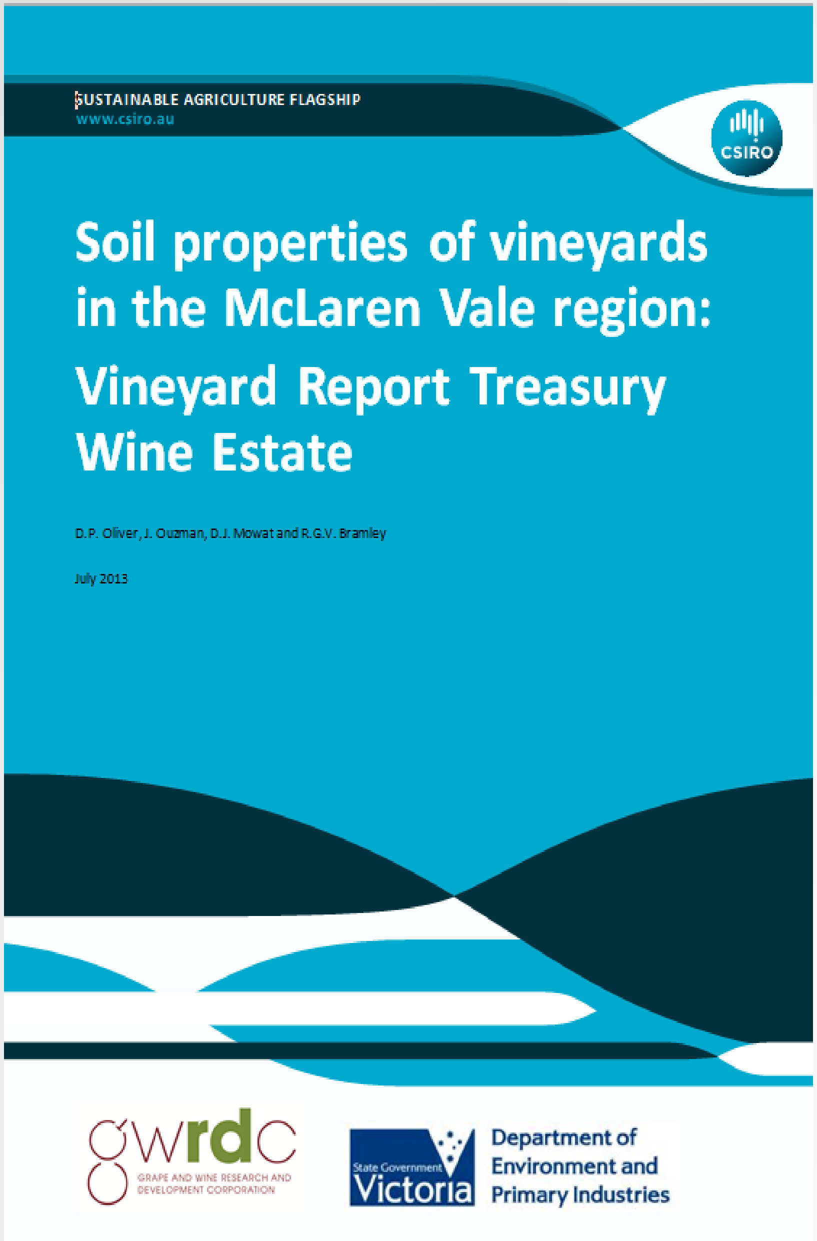
Large Standardized Databases from 4 Key Regions – A first for industry!

BR1 | fx | W-B Org C (%)

	A	B	C	DH	DI	DJ	DK	DL	DM	DN	DO	DP	DQ	DR	DS	DT	DU	DV	DW	DX	DY	DZ	EA	EB	EC
1	Number	Sample Code	Other ID	Paddock Position	CEC 30 - 60 cm	Total Inorg N (mg/kg) 30-60cm	Total S (mg/kg) 30-60 cm	Colwell P (mg/kg) 30-60cm	Bic-K (mg/kg) 30-60cm	Ex cats-Na 0-10 cm	Ex cats-Na 35-45 cm	Ex cats-Mg 0-10 cm	Ex cats-Mg 35-45 cm	Ex cats-Ca 0-10 cm	Ex cats-Ca 35-45 cm	Ex cats-K 0-10 cm	Ex cats-K 35-45 cm	ESP (%) 0-15 cm	ESP (%) 35-45 cm	Chloride 0-15 cm	Chloride 35-45 cm	Colour surface soil	Colour subsurface soil	Texture subsurface	Consister surface s
2	220	MV1 UV		Under Vine	24.44	4	14.6	6	331	<0.10	0.93	0.33	5.26	7.33	17.39	0.37	0.86	0.62	3.81	31.8	10.8	BR	BR	3	3
3	221	MV1 MID		Mid Row	23.08	7	29.6	4	468	0.12	0.68	2.49	4.52	15.53	16.67	0.67	1.21	0.64	2.95	18.6	24	BR	LTBR	3	5
4	222	MV1 NAT		Native	20.69	7	6	7	315	<0.10	9.53	3.21	1.9	16.22	8.6	1.23	0.6	0.24	43.31	38.8	7.2	BR	BR	3	4
5	223	MV2 UV		Under Vine	14.58	3	43.2	6	1107	0.21	1.38	1.34	5.34	5.75	5.7	0.69	2.16	2.63	9.47	188.4	240.7	BRGR	BROR	3	3
6	224	MV2 MID		Mid Row	9.89	4	74	8	410	<0.10	0.17	0.31	3.48	4.85	5.3	0.46	0.94	0.88	1.72	52.4	14.4	GRBR	OR	3	3
7	225	MV2 NAT		Native	17.87	6	5.2	9	1086	<0.10	0.32	2.54	4.41	11.37	11.01	1.44	2.13	0.33	1.79	106.1	9.3	GRBR	DKBR	3	4
8	228	MV3 UV		Under Vine	16.99	3	48.1	7	70	<0.10	0.34	1.39	1.4	15.11	15.09	0.67	0.16	0.29	2.00	437.1	424.1	BRRD	BRWH	2.5	2
9	229	MV3 MID		Mid Row	16.87	4	9.1	5	69	<0.10	<0.10	0.79	1.1	17.15	15.54	0.43	0.18	0.27	0.30	71.5	4.6	BRRD	GRPK	2.5	2
10	230	MV3 NAT		Native	19.96	5	19.5	6	293	<0.10	0.54	1.72	2.63	9.42	15.89	0.97	0.9	0.41	2.71	178	212.1	BRRD	BRRD	3	2
11	231	MV4 UV		Under Vine	27.46	7	121.4	6	122	0.1	1.38	3.19	4.16	13.23	21.42	1.56	0.5	0.36	5.03	161.2	841.2	BRRD	BRGR	3	2
12	234	MV4 MID		Mid Row	26.51	2	8.6	5	125	0.11	0.55	2.53	3.88	14.74	22.91	1.3	0.42	0.59	2.48	89.1	211.4	BRRD	BROR	3	3
13	235	MV5 UV		Under Vine	17.76	5	320.8	8	101	0.15	0.3	2.3	1.29	25.71	15.91	2.34	0.26	0.49	1.69	57.8	196.4	DKBR	LTBR	3	3
14	236	MV5 MID		Mid Row	18.48	1	118.3	3	88	<0.10	0.44	2.4	2.1	26.31	15.6	1.94	0.34	0.16	2.38	80	113.8	BRGR	BRWH	3	4
15	239	MV6 UV		Under Vine	25.89	2	88.7	5	326	<0.10	0.45	0.89	4.36	13.53	19.9	1.65	1.18	0.31	1.74	109.7	84.7	BR	DKBR	3	4
16	240	MV6 MID		Mid Row	23.31	4	3	3	415	<0.10	1.44	0.79	4.85	12.23	15.62	0.78	1.4	0.36	6.18	42.5	34.4	BR	BRRD	3	3
17	241	MV6 NAT		Native	21.84	3	33.4	3	578	0.15	1.32	3.75	6.02	17.5	13.01	1.27	1.4								2
18	242	MV7 UV		Under Vine	35.35	5	22.5	6	294	0.65	4.16	6.76	6.6	16.91	23.32	1.89	1.2								5
19	243	MV7 MID		Mid Row	31.51	5	3.6	16	302	0.12	1.48	3.32	3.95	17.89	24.81	1.74	1.2								2
20	244	MV7 NAT		Native	32.21	6	7.4	5	374	<0.10	2.46	1.55	4.82	13.38	23.28	0.87	1.6								2
21	245	MV8 UV		Under Vine	16.65	8	70.7	6	131	<0.10	0.27	2.11	3.06	14.03	12.95	1.74	0.3								2
22	248	MV8 MID		Mid Row	30.57	10	4.8	34	148	<0.10	9.24	1.69	1.41	15.09	19.36	2.04	0.5								4
23	249	MV8 NAT		Native	•	•	•	•	•	<0.10	•	1.44	•	14.25	•	1.3	•								4
24	250	MV9 UV		Under Vine	25.42	4	76.4	4	432	0.13	2.22	1.78	6.25	5.22	15.55	0.56	1.								5
25	251	MV9 MID		Mid Row	27.12	7	7	6	435	<0.10	0.65	1.19	6.96	6.08	17.89	0.61	1.6								4
26	252	MV9 NAT		Native	31.23	12	4.2	4	389	<0.10	0.75	1.45	4.08	13.11	24.69	79	1.7								4
27	253	MV10 UV		Under Vine	9.18	<1	3.9	6	25	<0.10	3.36	0.42	0.33				3.8								1
28	254	MV10 MID		Mid Row	12.19	1	3.8	6	21	<0.10	0.22	0.36	0.7	2.02	5.84	05	8.8								0
29	255	MV11 UV		Under Vine	2.64	<1	1.9	4	23	<0.10	0.16	0.32	0.49	2.48	5.92	0.02	0.								0
30	256	MV11 MID		Mid Row	9.06	<1	2	8	18	<0.10	1.46	0.28	7.16	3.24	0.4	0.06	0.0								0
31	257	MV11 NAT		Native	8.19	<1	2	<2	27	<0.10	1.99	0.97	0.13	1.94	0.41	0.09	5.6								1
32	258	MV12 UV		Under Vine	8.25	1	8.3	24	32	<0.10	2.14	0.88	0.28	4.41	1.06	0.11	4.7								0

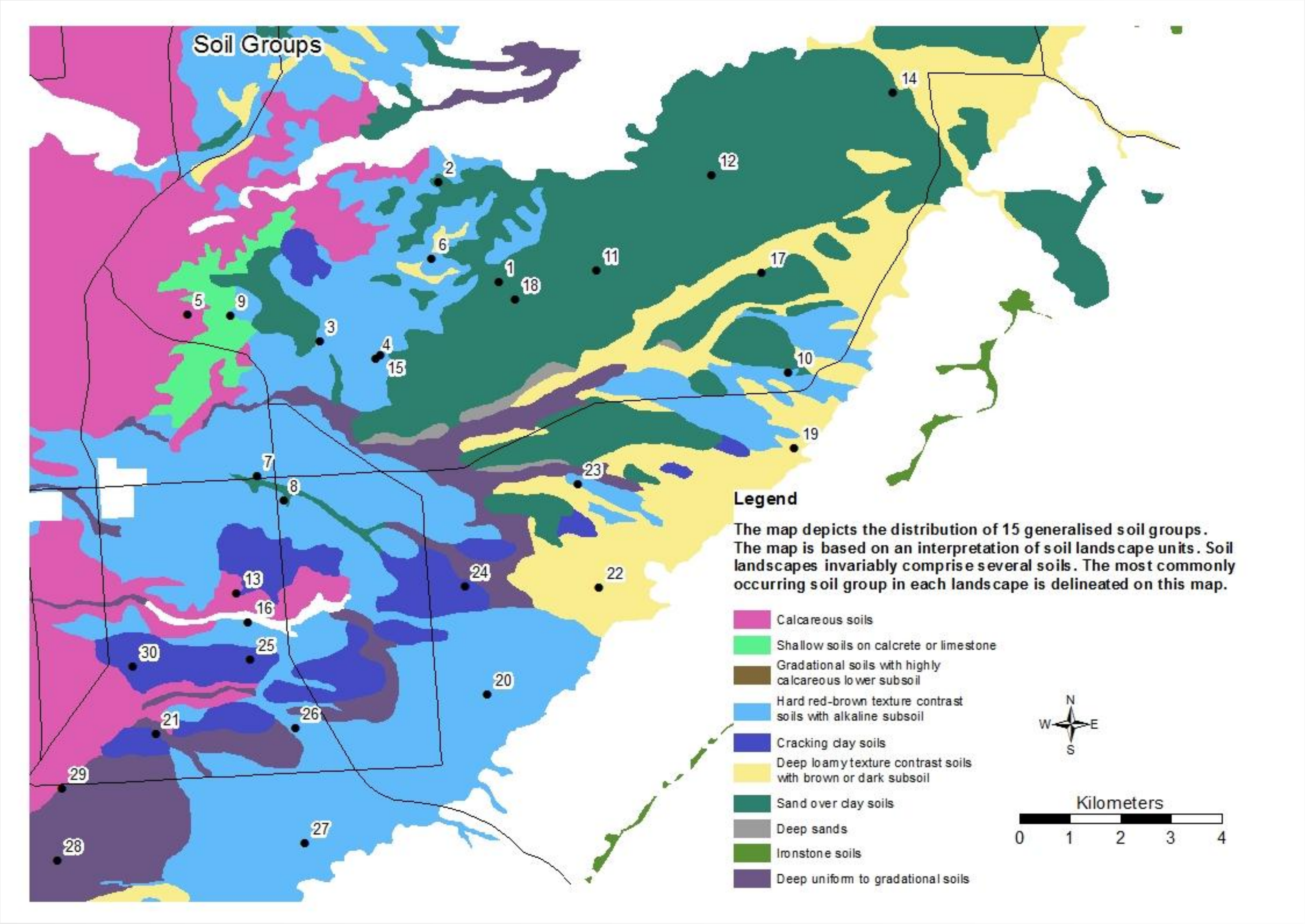
SQI-Group 52 (McLaren Vale)





Individual property data collected which can be related to regional averages.

i. Often identified constraints and issues needing to be managed
ii. Lead to improvements in vineyard performance



Soil characteristics of McLaren Vale region

Inherent Soil Properties

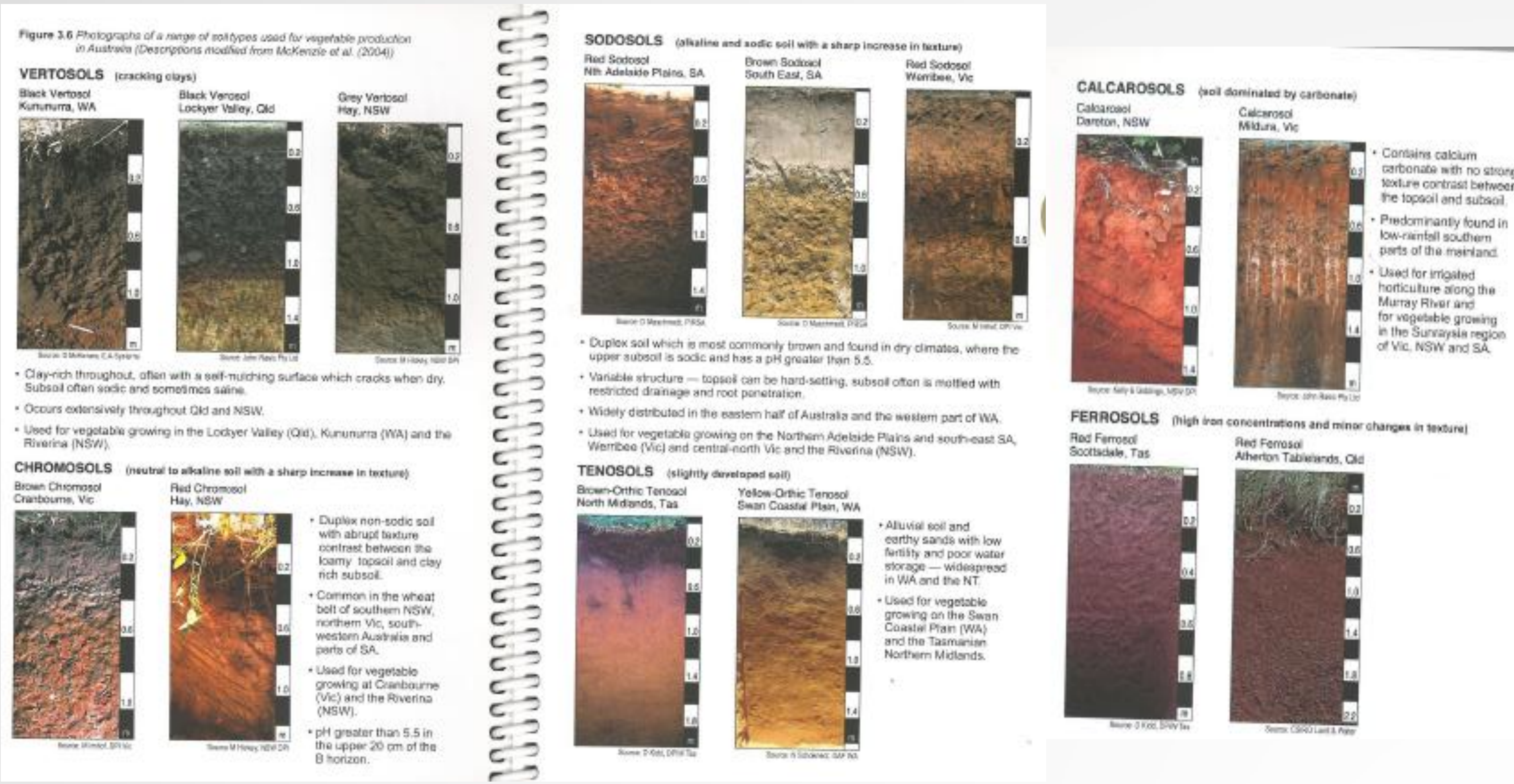


Figure 3.6 *Photographs of a range of soil types used for vegetable production in Australia (Descriptions modified from McKenzie et al. (2004))*

VERTOSOLS (cracking clays)

Black Vertosol, Kununurra, WA — Black Vertosol, Lockyer Valley, Qld — Grey Vertosol, Hay, NSW

- Clay-rich throughout, often with a self-mulching surface which cracks when dry. Subsoil often sodic and sometimes saline.
- Occurs extensively throughout Qld and NSW.
- Used for vegetable growing in the Lockyer Valley (Qld), Kununurra (WA) and the Riverina (NSW).

CHROMOSOLS (neutral to alkaline soil with a sharp increase in texture)

Brown Chromosol, Cranbourne, Vic — Red Chromosol, Hay, NSW

- Duplex non-sodic soil with abrupt texture contrast between the loamy topsoil and clay rich subsoil.
- Common in the wheat belt of southern NSW, northern Vic, south-western Australia and parts of SA.
- Used for vegetable growing at Cranbourne (Vic) and the Riverina (NSW).
- pH greater than 5.5 in the upper 20 cm of the B horizon.

SODOSOLS (alkaline and sodic soil with a sharp increase in texture)

Red Sodosol, Nth Adelaide Plains, SA — Brown Sodosol, South East, SA — Red Sodosol, Werribee, Vic

- Duplex soil which is most commonly brown and found in dry climates, where the upper subsoil is sodic and has a pH greater than 5.5.
- Variable structure — topsoil can be hard-setting, subsoil often is mottled with restricted drainage and root penetration.
- Widely distributed in the eastern half of Australia and the western part of WA.
- Used for vegetable growing on the Northern Adelaide Plains and south-east SA, Werribee (Vic) and central-north Vic and the Riverina (NSW).

TENOSOLS (slightly developed soil)

Brown-Orthic Tenosol, North Midlands, Tas — Yellow-Orthic Tenosol, Swan Coastal Plain, WA

- Alluvial soil and earthy sands with low fertility and poor water storage — widespread in WA and the NT.
- Used for vegetable growing on the Swan Coastal Plain (WA) and the Tasmanian Northern Midlands.

CALCAROSOLS (soil dominated by carbonate)

Calcarosol, Dareton, NSW — Calcarosol, Mildura, Vic

- Contains calcium carbonate with no strong texture contrast between the topsoil and subsoil.
- Predominantly found in low-rainfall southern parts of the mainland.
- Used for irrigated horticulture along the Murray River and for vegetable growing in the Sunraysia region of Vic, NSW and SA.

FERROSOLS (high iron concentrations and minor changes in texture)

Red Ferrosol, Scottsdale, Tas — Red Ferrosol, Atherton Tablelands, Qld

1. Individualized Grower Comparisons to the Regional Average (undervine, midrow cf. undisturbed native sites)

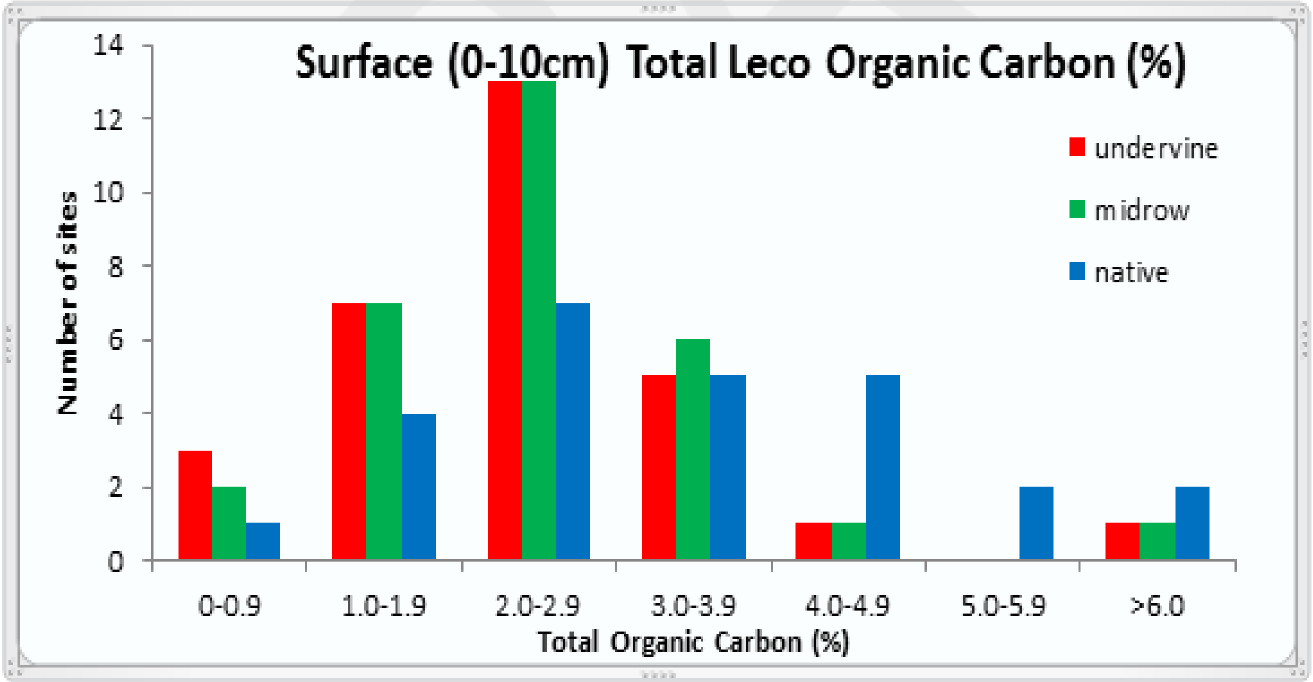
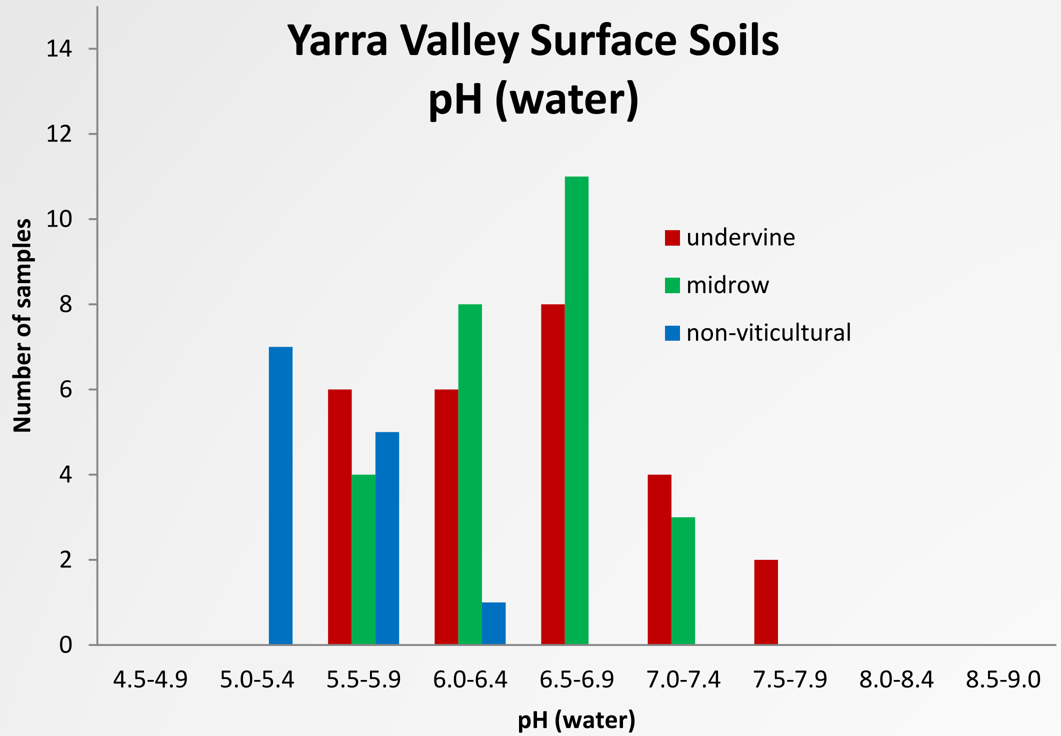


Fig. 5 Chart Area of total organic carbon (Leco) in surface soils (0-10 cm) for 30 McLaren Vale sites sampled in 2013.

Table 9 Results of total organic carbon (Leco) in surface soils (0-10 cm) for Treasury Wine Estate sites and McLaren Vale average.

Location	undervine	midrow	native
Regional Average	2.48	2.58	3.48
Site 1	1.96	2.85	3.37
Site 2	1.64	2.18	2.19

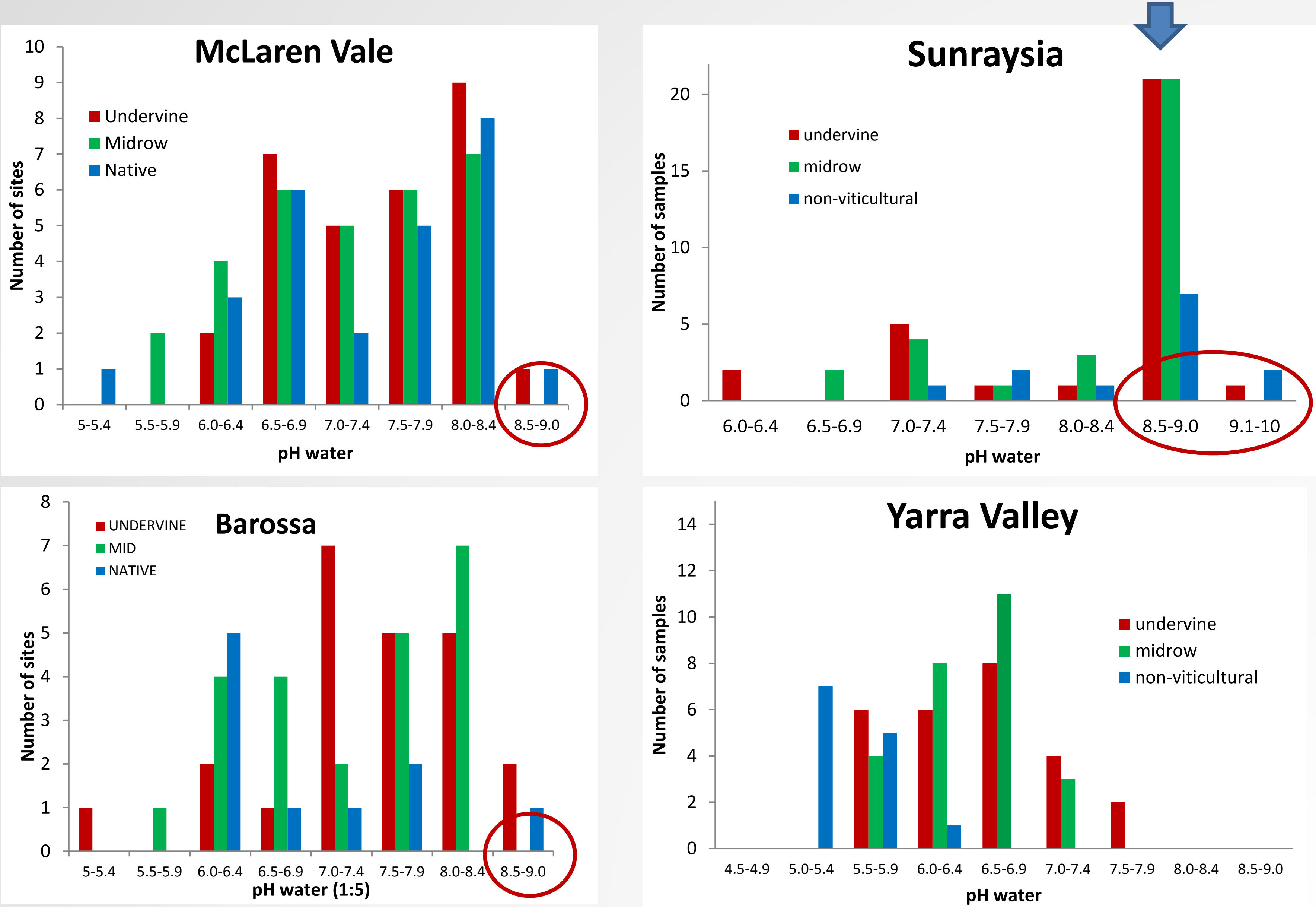
2. Impact of Viticultural Practices cf. Natural Conditions



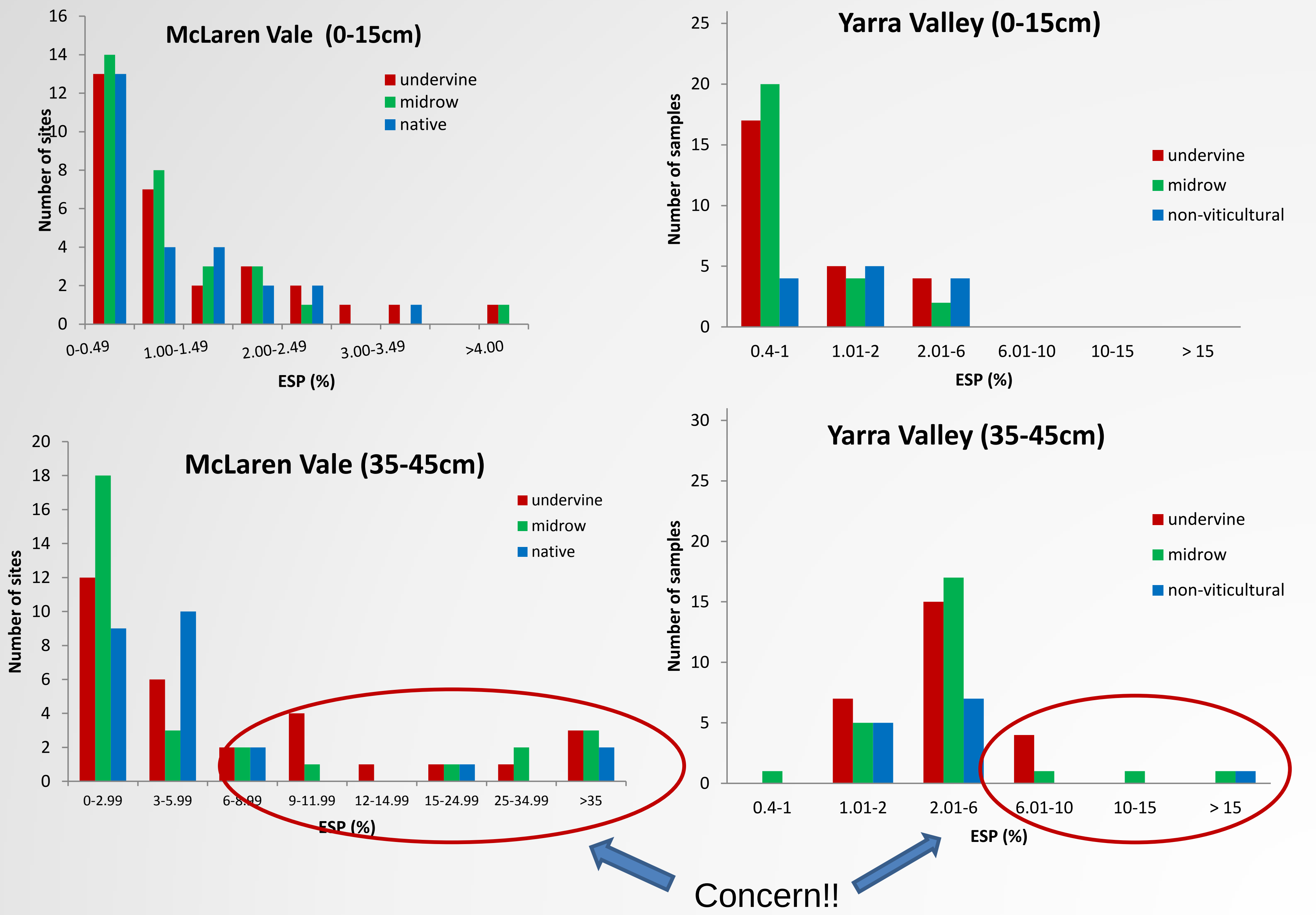
Production shift cf native in soil pH

Position	Mean	Range	Ideal range
Undervine	6.5	5.5 – 7.6	5.5 – 8.0
Midrow	6.5	5.7 – 7.4	5.5 – 8.0
Non-viticultural	5.5	5.0 – 6.4	

3. Regional Comparison: Surface Soils pH (H_2O) at 0-15cm



4. Identification of subsoil constraints: Exchangeable Sodium Percentage (ESP) (%)



5. Identification of Potential Constraints/Problems

4.1.2 SUB-SURFACE SOILS – CHEMICAL DATA

Table 3 Results of analyses in sub-surface soils (35-45 cm) for sites and McLaren Vale average.

Location	Ammonium Nitrogen mg/kg	Nitrate Nitrogen mg/kg	P[1] Colwell mg/kg	K[2] Colwell mg/kg	Sulphur mg/kg	Organic Carbon %	Conduct-ivity dS/m	pH Level ($CaCl_2$)	pH Level (H_2O)	Chloride mg/kg	Exch Ca^3	Exch K^3	Exch Mg^3	Exch Na^3	CEC_e[4]	ESP[5]
Undervine																
Regional	1.23	2.53	13.7	229.1	50.43	0.68	0.27	7.1	7.9	149.4	11.9	1.15	3.46	1.22	17.8	9.78
Site 1	0.50	2.00	3.0	222.0	58.20	0.86	0.16	7.6	8.3	18.1	20.3	0.75	4.30	0.30	25.6	1.17
Site 2	2.00	2.00	4.0	432.0	76.40	0.81	0.45	7.0	7.8	162.6	15.6	1.40	6.25	2.22	25.4	8.73
Midrow																
Regional	1.81	2.62	12.2	209.9	28.56	0.69	0.13	6.8	7.6	30.1	12.2	0.84	3.35	1.28	17.7	9.93
Site 1	2.00	4.00	4.0	258.0	23.30	1.32	0.16	7.6	8.4	20.3	26.0	1.01	5.51	0.34	32.9	1.03
Site 2	3.00	4.00	6.0	435.0	7.00	0.92	0.23	6.7	7.7	4.9	17.9	1.62	6.96	0.65	27.1	2.40
Native																
Regional Average	1.14	2.86	6.0	296.1	16.68	0.84	0.27	6.9	7.8	200.9	12.1	1.30	3.06	1.23	17.7	7.60
Site 1	1.00	3.00	4.0	241.0	6.20	1.18	0.10	7.8	8.6	18.9	21.9	0.82	4.70	0.27	27.7	0.98
Site 2	4.00	8.00	4.0	389.0	4.20	1.04	0.16	7.4	8.2	9.3	24.7	1.71	4.08	0.75	31.2	2.40

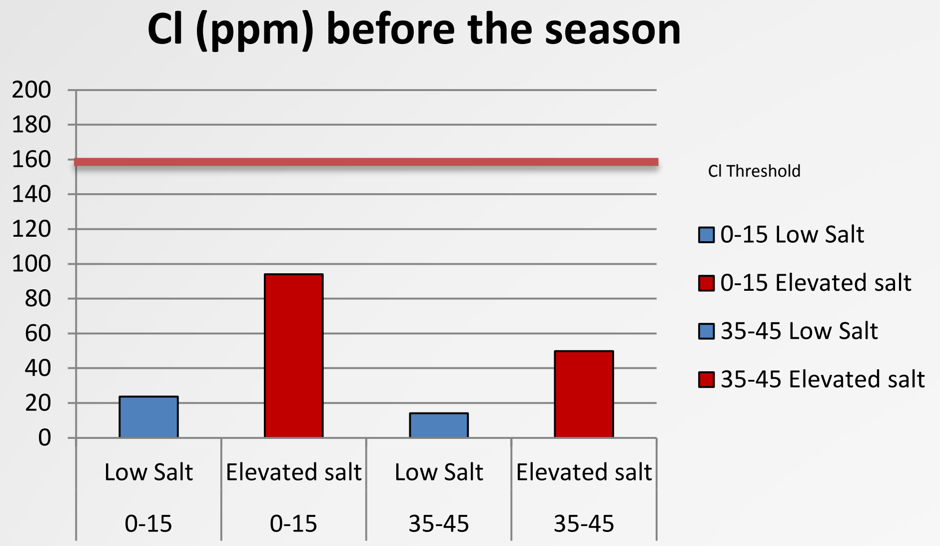
[1] P=phosphorus; [2]K=potassium; [3] Exchangeable cations determined with a pre-wash; results in meq/100g; 1 meq/100g=1cmol/kg; [4]CEC=cation exchange capacity; [5]ESP=exchangeable sodium percentage

<175 ppm

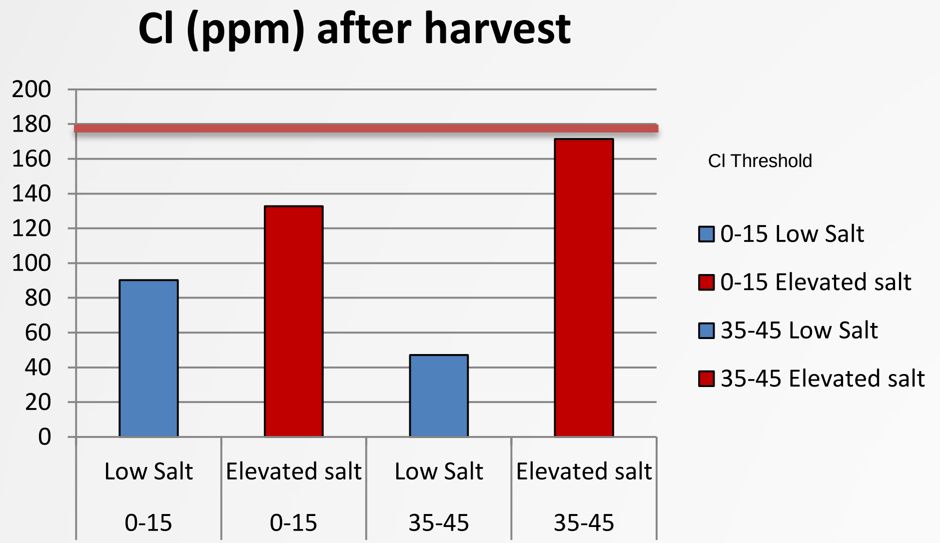
<6%ESP

Field trial and paired site results. Example of how to use soil tests to help manage a constraint

Timing of Soil Tests Important - Standardization required!



Thresholds
- 175ppm Cl
- <6% Exch. Na%



Project Outcomes to assist Management of a Constraint

1. Indicators were able to predict extent of salinity
2. Indicator tests correlated with yield/wine quality
3. Simple economic models were developed to show benefit to grower/industry

Wine quality

Soil Indicator set

Yields

	High Salt	Moderate	No Salt
Cl (ppm) in soil (0-15cm)	1383	1355	178
No harvested	82	87	134
No dropped	9	10	0
Yield (kgs)	4.48	5.68	13.92

Cabernet

Threshold <175 ppm Cl is OK

Salinity site (Cl in ppm): Undervine cf. Mid row cf. Native

Treatment	Undervine	Mid row	Native	Undervine	Mid row	Native
Depth (cm)	**0-15**	**0-15**	**0-15**	**35-45**	**35-45**	**35-45**
Low salt	178	39	90	99	78	69
Mod salt	1355	273		492	303	
High salt	1383	1526		704	1319	
Regional Average	28.5	23.7	36.4	26.3	19.6	20.3

Threshold >175 ppm of concern for grapes

NU-test nutrient uptake

Wine Grape Petioles
Pinot Noir
REPORT

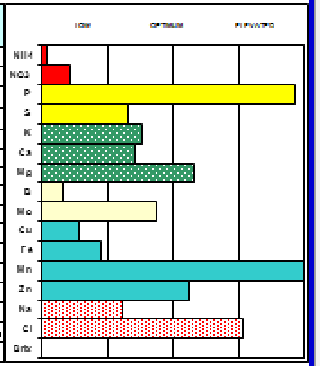
AGVITA ANALYTICAL

ABN 58 129 916 310
PO Box 188,
Devonport, TAS, 7310
Ph: +61 364 209 600
Fax: +61 364 270 230
mailto:info@agvita.com.au

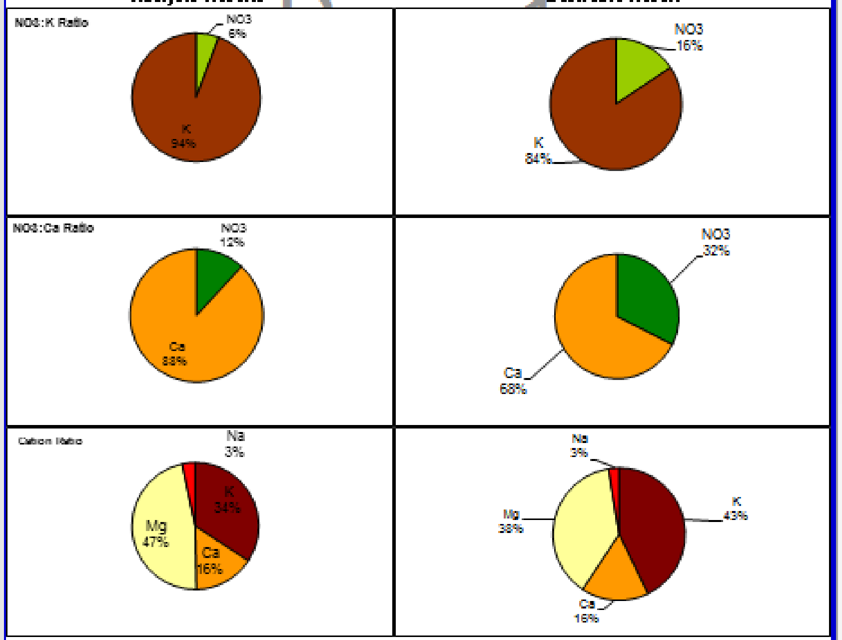
Client Name:	YERING STATION
Paddock/Block:	No Salt Ave
Agronomist:	0
Report date:	07/02/13
Growth stage	GS 8.1

Results [ppm]:

NUTRIENT		DESIRABLE		RESULT	STATUS
		High	Low		
Ammonium -	NH4	100	15	2.753	
Nitrate -	NO3	700	225	115.8	Low
Phosphorus -	P	350	100	501.8	Elevated
Sulphur -	S	250	100	131.8	Satisfactory
Potassium -	K	3500	1500	1905	Satisfactory
Calcium -	Ca	1350	575	862.5	Satisfactory
Magnesium -	Mg	2750	1700	2608	Optimum
Boron -	B	4.00	2.00	0.503	Low
Molybdenum -	Mo	0.04	0.02	0.03	Satisfactory
Copper -	Cu	2.5	0.8	0.583	Low
Iron -	Fe	5.0	1.8	1.785	Marginal
Manganese -	Mn	6.0	2.0	34.6	Excessive
Zinc -	Zn	10.00	4.0	10.05	Optimum
Sodium -	Na	300	50	185.8	Marginal
Chloride -	Cl	2000	20	2443	Moderately saline
brix	%	14	10	0	-



Analysis Results | Desirable Result



NU-test nutrient uptake

Wine Grape Petioles
Pinot Noir
REPORT

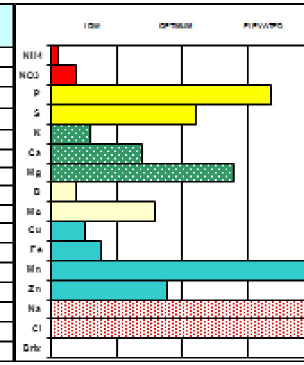
AGVITA ANALYTICAL

ABN 58 129 916 310
PO Box 188,
Devonport, TAS, 7310
Ph: +61 364 209 600
Fax: +61 364 270 230
mailto:info@agvita.com.au

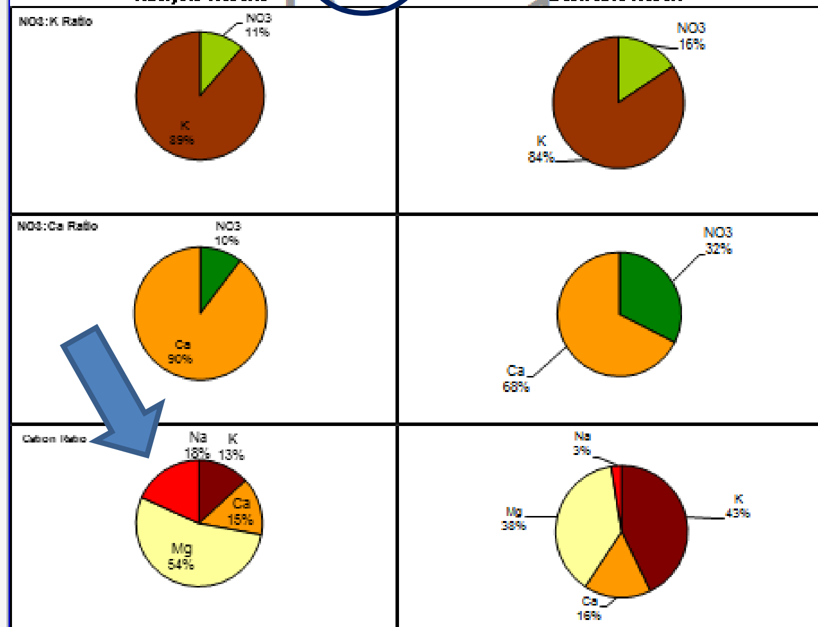
Client Name:	YERING STATION
Paddock/Block:	Salty Untreated
Agronomist:	0
Report date:	07/02/13
Growth stage	GS 8.1

Results [ppm]:

NUTRIENT		DESIRABLE		RESULT	STATUS
		High	Low		
Ammonium -	NH4	100	15	3.813	
Nitrate -	NO3	700	225	98.5	Low
Phosphorus -	P	350	100	438	Elevated
Sulphur -	S	250	100	220.3	Optimum
Potassium -	K	3500	1500	764.8	Low
Calcium -	Ca	1350	575	857.5	Satisfactory
Magnesium -	Mg	2750	1700	3131	Optimum
Boron -	B	4.00	2.00	0.628	Low
Molybdenum -	Mo	0.04	0.02	0.028	Satisfactory
Copper -	Cu	2.5	0.8	0.528	Low
Iron -	Fe	5.0	1.8	1.538	Low
Manganese -	Mn	6.0	2.0	34.87	Excessive
Zinc -	Zn	10.00	4.0	7.985	Satisfactory
Sodium -	Na	300	50	1061	Elevated
Chloride -	Cl	2000	20	4823	Highly saline
brix	%	14	10	0	-



Analysis Results | Desirable Result



Analysis by AgVita Analytical
The information within this report should be used as part of a crop-monitoring program and under consideration of particular production conditions. Desirable levels are derived from ongoing research carried out by AgVita Analytical Pty. Ltd. The interpretation of analytical results presumes specific sampling, sample handling, extraction and analytical procedures. Results may be incompatible with interpretation aides developed via different procedures. AgVita Analytical Pty. Ltd and its employees or agents will not be liable for any loss or damage arising from application or interpretation of the data supplied. Please seek guidance on local interpretations and recommendations from your agronomist.

Economic model

Salinity trial as a case study (Cab Savignon)

	Outcome	No Bunches/panel	Yield/panel or bunch weight	Be	pH	TA	Loss	Loss at 700L/tonne &$8/bottle	Loss at $2000/tonne
Site 9	Good	134	13.92		3.50	7.22	-	-	
	Moderate (threshold)	87	5.68		3.28	6.05	59.2%	$4420/tonne	$1180/tonne
	Bad	82	4.48		3.28	6.05	67.8%	$5061/tonne	$1356/tonne

- **Management**

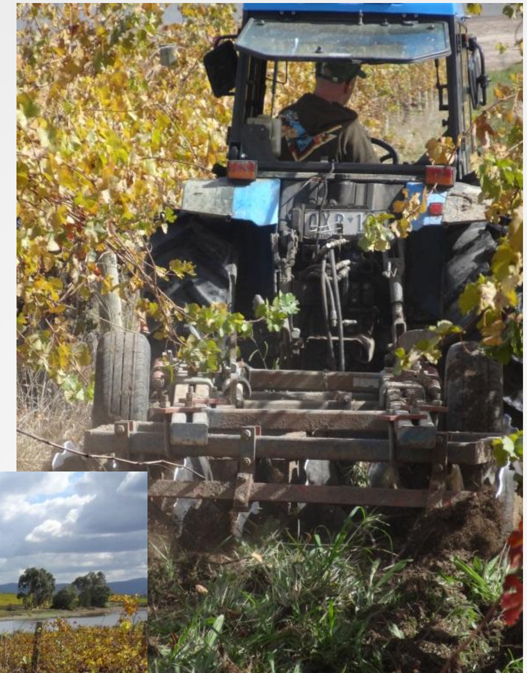
1. Drip irrigate with Ca thiosulphate, etc.
2. Deep rip?
3. Add gypsum or lime

<$500-700/ha

4. Deep- rip and add compost
5. Mole drains with compost
6. Add feather drains to get rid of salt

<$16,000/ha


AUSSIE-DRAIN



Effective use of soil tests and management to solve a salinity issue

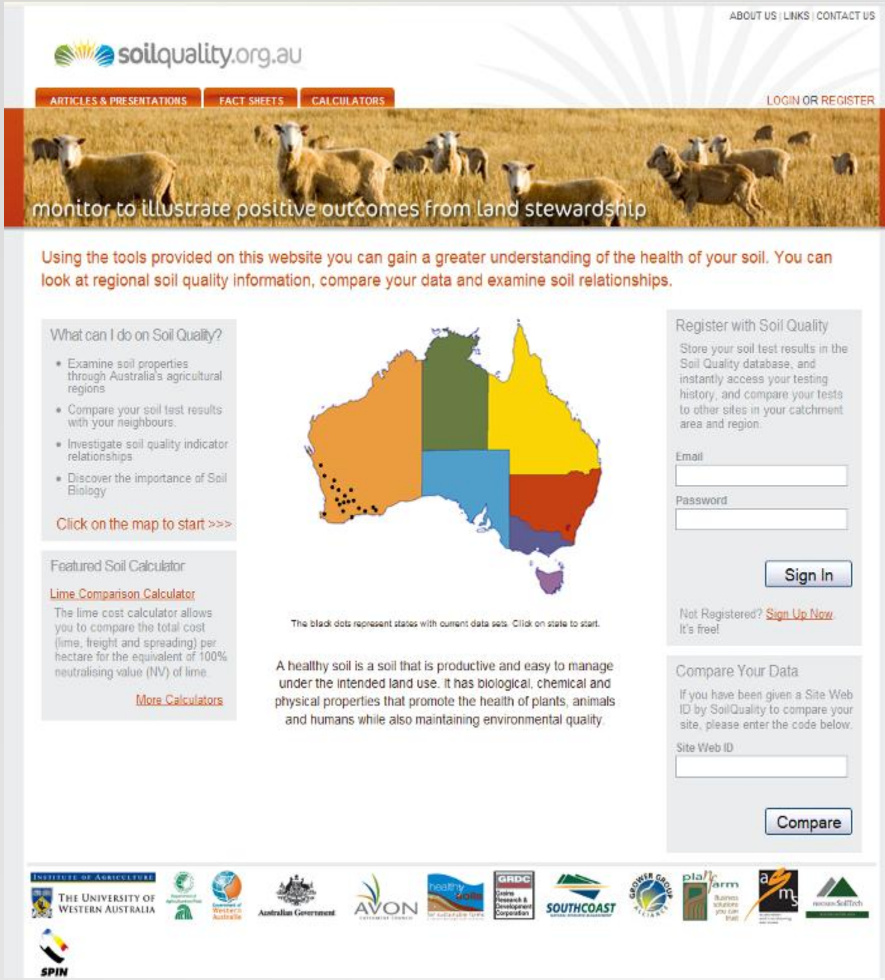
Parameter	Salt affected	Feather drains
Chlorine (ppm)	1010	10
EC (ds/m)	0.86	0.15
pH	7.1	7.4
Ca	16.8%	14%
ESP (Na)	12%	2.4%

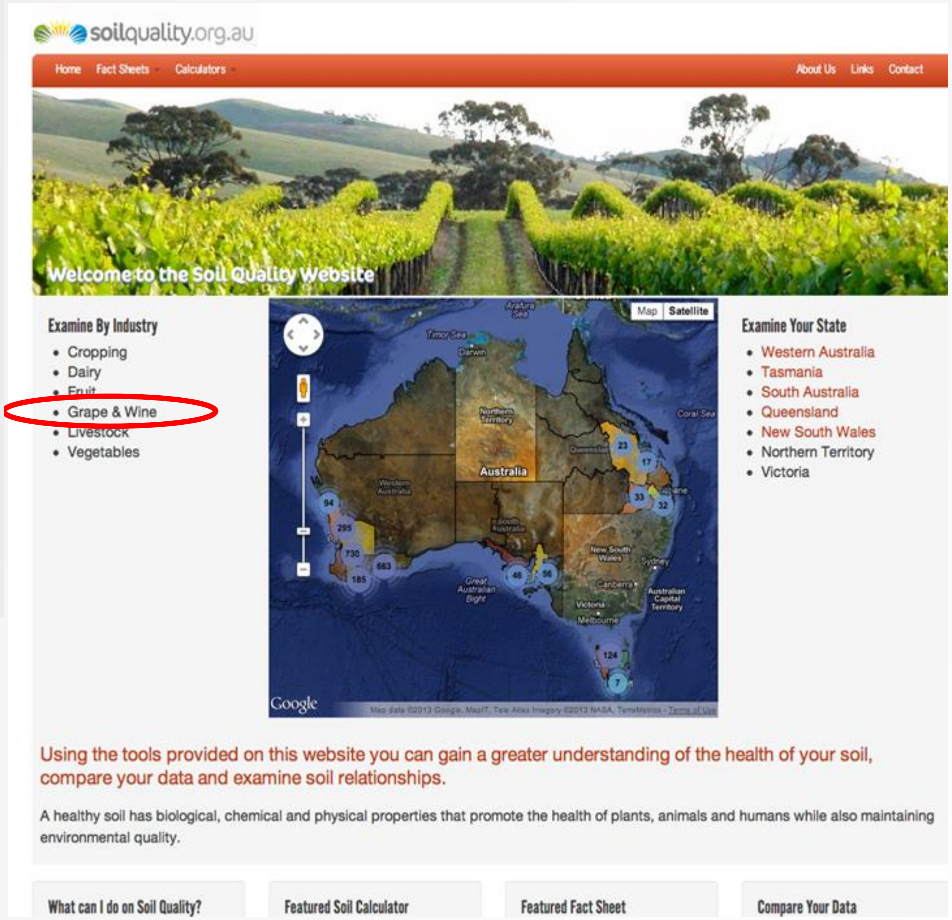
Paired Sites: Relating soil qualities to yield and wine quality

	Outcome	No Bunches/ panel	Yield/panel or bunch weight	Be	pH	TA
Punt Road	Good	155	17.04	11.90	3.50	7.22
	Bad	133	12.34	11.55	3.28	6.05
De Bortoli 1	Good		250	12.9	3.37	6.1
	Bad		200	13.4	3.41	5.1
De Bortoli 2	Good		230g	12.5	3.35	5.0
	Bad		140g	13.5	3.22	5.0
Helens Hill	High quality	128	8.58	13.4	3.64	4.9
	Low quality	178	12.64	13.0	3.73	4.4

Parameter	Threshold
Baume	12-14.5
pH	3.3-3.5
Titratible acidity	>6.5

Module on the National Soil Quality Website





soilquality.org.au

MAKING SENSE OF BIOLOGICAL INDICATORS

Biology

Biological indicators give information on living organisms in soil. Biological indicators of soil quality therefore measure *dynamic* soil properties, i.e. properties that change over time and/or with management. It is important to monitor biological indicators as they respond more quickly to changes in management or environment than physical and chemical indicators.

For most biological indicators, there is little evidence currently available which directly links the value of the indicators to productivity or, in some cases, the risk of adverse environmental impact. However, there is good evidence from field trials carried out on a range of soils in Australia of links between biological indicators and soil processes. These have been used to create guideline ranges for the biological indicators, similar to those used for the dynamic physical and chemical indicators.

- Indicators falling in the RED zone are high risk and need to be investigated urgently.
- Indicators falling in the AMBER zone are moderate risk and should be investigated further.
- Indicators falling in the GREEN zone are low risk, regular monitoring should be continued.

Diseases and Nematodes

Indicators of soil inoculum status for soil borne disease and/or nematode abundance are used to guide practical paddock by paddock decisions about using control measures. The pathogen–host cycles are complex and affected by a range of environmental, crop and management factors (see Take-all Disease, Cereal Cyst Nematode, Root Lesion Nematode fact sheets). Because the pathogens are highly variable across a paddock, it is very important to use an appropriate sampling strategy to gain results that are representative of the paddock (figures 1 & 2). A medium or high value obtained as part of routine soil monitoring may not lead to a high risk of the disease or significant yield loss. Approaches to managing pathogens need to be specific to each paddock and farmers should seek the advice of an appropriately qualified agronomist.

Figure 1: Cereal cyst nematode will cause distinct patches of yellowed and stunted plants. Note the likeness of symptoms to poor nutrition or water stress. (Photo by Vivien Vanstone, DAFWA, Nematology.)

Figure 2: Patchiness in crop caused by Root lesion nematode. (Photo by Vivien Vanstone, DAFWA, Nematology.)

Risk rating for Disease and Nematodes

below detection	low	medium	high

rganic carbon

matter in soil refers to all the materials that are associated with living organisms. It is difficult ure directly and total organic carbon (usually d as %C—the percentage of carbon in the soil), is d instead. The value for total organic carbon can rted to give tonnes of carbon per hectare using on about bulk density and gravel content (see anic Carbon fact sheet). Low levels of total organic an indicate that there might be problems with soil structure, low cation exchange capacity and urnover. Where total organic carbon in a paddock than the soil's capacity to store organic matter it ncreased by increasing ground cover, reducing etaining stubble, increasing the proportion of n the rotation or other management strategies ease inputs of organic materials into the soil.

Total organic carbon (%C) in sand soil

0.5	1.0	1.5

Total organic carbon (%C) in loam soil

0.5	1.0	1.5

Total organic carbon (%C) in clay soil

0.5	0.7	1.0	1.5	1.75

Total organic carbon can be separated into it (termed fractions or pools) which differ in structure. The labile pool which turns over re (<5 years), results from the addition of fresh as plant roots and living organisms. In con residues are slower to turn over (20–40 years are physically or chemically protected. Soi also contain charcoal as a result of burning w totally recalcitrant. The proportion of total o in the labile fraction can be used to identify amounts of regular residue input. In sand so total organic carbon should ideally be in the in loam soils 15% and in clay soils 20%.

Microbial biomass

The size of the soil microbial biomass mg C per kg) is affected by climate and many (see Microbial Biomass fact sheet). Microb the powerhouse of almost all biological pr (figure 3). Generally up to 5% of the total orga be found in the living tissues of the microbia

Microbial biomass (mg C/kg soi

100	200	30

Microbial biomass (% of total organic

1	2	3	4

The main soil properties affecting the microbial biomass and factors influenced by it.

Author: **Elizabeth Stockdale** (Newcastle University, UK)
Prepared based on findings from soil quality expert panel workshops

wheatbelt natural resource management

CARING FOR OUR COUNTRY

soilquality.org.au

MAKING SENSE OF CHEMICAL INDICATORS

Chemistry

Most indicators of soil chemical quality measure *dynamic* soil properties i.e. properties that change over time and with management. These indicators are used to guide management decisions over the period of a rotation. It is important to monitor these indicators as they can act as constraints to yield, restricting crop growth and preventing the yield potential from being achieved.

- Indicators falling in the RED zone are high risk and need to be investigated urgently.
- Indicators falling in the AMBER zone are moderate risk and should be investigated further.
- Indicators falling in the GREEN zone are low risk, regular monitoring should be continued.

Soil pH (acidity and alkalinity)

pH is a measure of the concentration of hydrogen ions in the soil solution. The pH unit scale runs from 1 to 14, with 1 being most acid and 14 being most alkaline; soils normally fall in the range 3–8. Acidic soils can restrict microbial activity, reduce the availability of essential nutrients and cause aluminium toxicity in the subsurface which retards root growth, restricting access to water and nutrients (figure 1) (see Soil Acidity fact sheet). Application of agricultural lime is effective in treating soil acidity. Some crops show greater tolerance of acid or alkaline conditions and rotations can be optimised to reduce the impact of pH constraints.

Topsoil pH in the acidic to neutral range

3.5	4.5	4.8	5.5	6.5

Subsurface soil pH in the acidic to neutral range

3.5	4.5	4.8	5.5	6.5

Figure 1: Aluminium toxicity retarded root growth of barley seedlings grown in acidic subsurface soil (pH 4.0) (right) compared to normal root growth in limed soil (pH 5.1) (left).

pH in the neutral to alkaline range

7.5	8	8.5	9	9.5

Electrical conductivity in topsoil

The concentration of soluble salts in the soil solution is measured by the electrical conductivity (EC) of the saturation extract. EC is expressed in units of deci siemens per metre (dS/m), known as ECe. Measurements of EC made in a 1-part soil to 5-part water suspension are first converted to ECe before comparison with the indicator values given below (see Electrical Conductivity fact sheet). EC is used to estimate the soluble salt concentration in soil, and is commonly used as a measure of salinity. The presence of high salt concentrations can stunt plant growth because water uptake by the roots is reduced by the increased osmotic potential of soil. Also, when salt concentration in the soil is high, there can be increased rates of leaf necrosis over the growing season. EC is very variable over time and across a paddock, so further investigations of the site should be carried out by an expert.

Electrical conductivity (ECe)

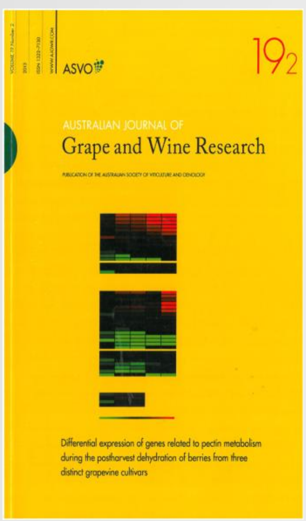
5	6	7	7.4	8	9

Water repellency

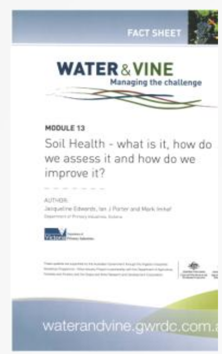
Water repellency occurs when the hydrophobic (or water repelling) waxy materials from plant residues decompose and coat soil particles. This can prevent water from entering the soil surface (figure 2). Water repellency typically occurs in soils with <10% clay. Sand soils are more prone to water repellency as it takes less hydrophobic material to coat individual particles. Water repellency is measured in the laboratory using the molarity of ethanol drop test (see Water Repellency fact sheet). The higher the strength of ethanol needed to penetrate the soil, the more severe the water repellency.

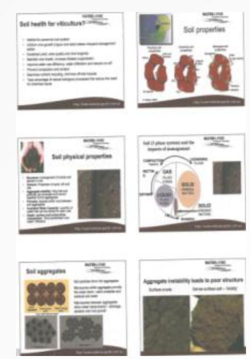
For those that want to read more!!

1. Two refereed review papers in Grape and Wine Research
2. 1 article in the ‘ANZ GW Magazine’
3. AWIT 2011 and 2013 – workshops. Interactive soil quality workshop conducted at the AWIT 2013 described as ‘Best Workshop Ever’
4. Twelve regional seminar sessions throughout the industry

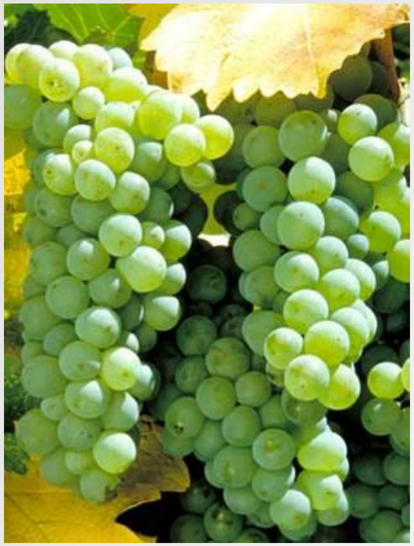



Review: soil physical and chemical properties as indicators of soil quality in Australian viticulture





Conclusion: Collecting data and use of a standardized indicator test can lead to information which will assist the industry manage soil quality, crop yields and wine quality



Productivity/yield

- Full range of indicator tests
- Remote sensing and yield mapping to soil qualities

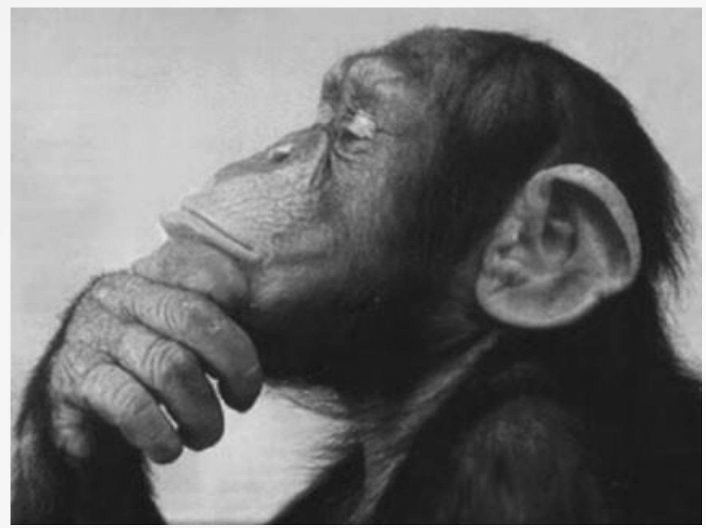
★★½	★★★	★★★½	★★★★	★★★★½	★★★★★	
75-79	80-83	84-86	87-89	90-93	94-97	98-100
12 14	15	15.5	16.5	17 18	19 19.5	20
NO MEDAL		BRONZE		SILVER	GOLD	GOLD

Wine quality

Benchmark and monitor a few specific traits of good areas of the vineyard and improve management for other areas!


Definitely The End!

How and what tests would you do to solve the problem?



How would you interpret the data?


Biodynamic


Cultivated


Covercrop


Undervine
Mulch

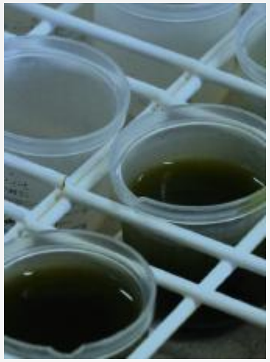
Range of Indicator Tests to assist to identify and overcome a constraint

Pre season soil

Petiole Tests at flowering/80% cap fall

Veraison sap

Berry samples

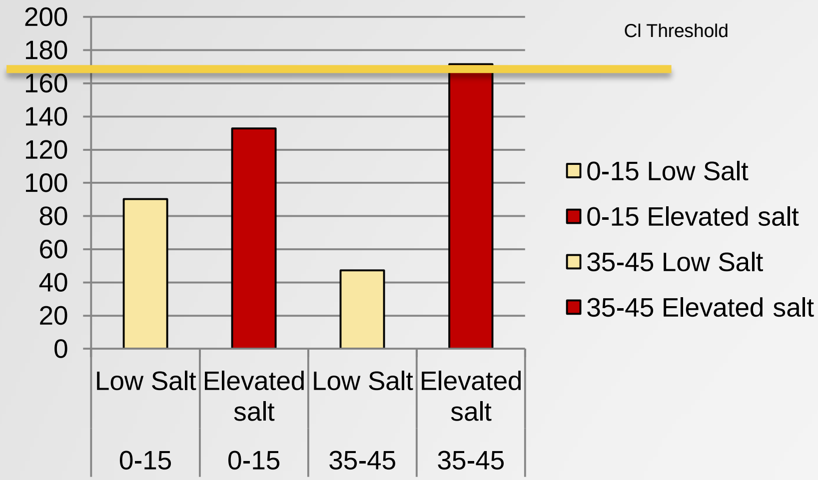


Wine juice

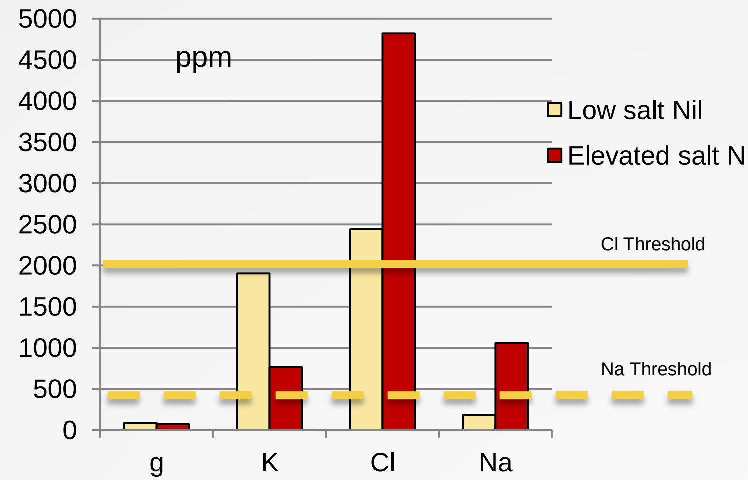
Post harvest soil

The post harvest soil test correlated well with the sap, grape and berry juice samples at harvest.

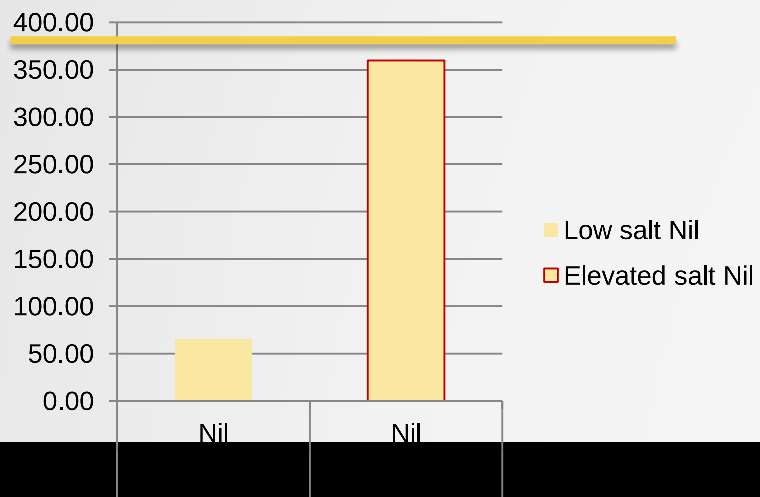
Cl (ppm) after harvest



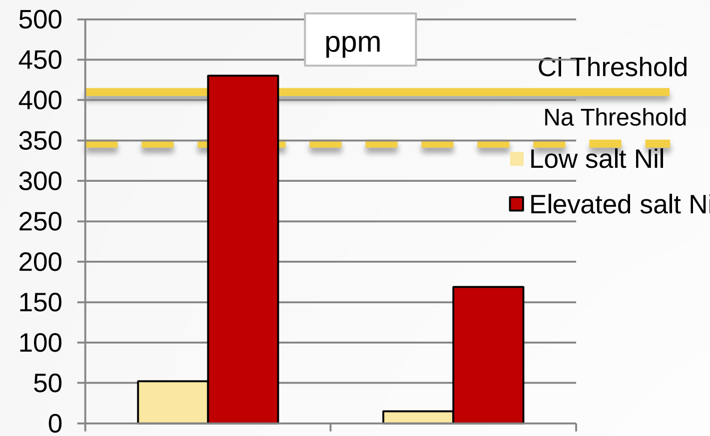
Petiole parameters



Dropped fruit Cl content



Thresholds in wine



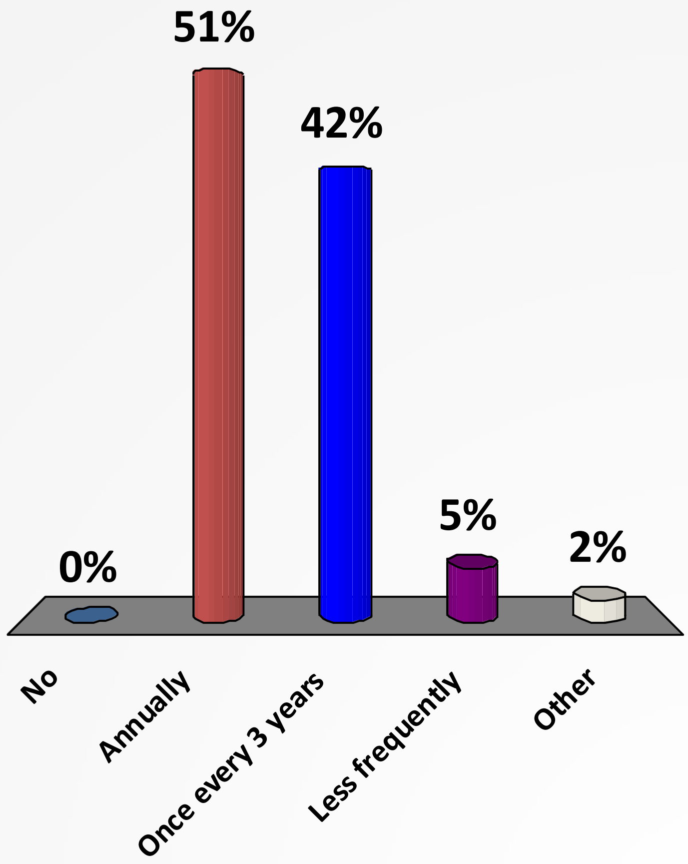
Standardised methodology

- Same time, same place, same method
- Approx 4 weeks after harvest
- Undervine, mid-row,   non-production
- Single panel; undervine: near dripper, approx 20 cm from trunks
-                    midrow: avoid machinery tracks
- Surface: 0-15 cm, 5 pooled cores – biol, chem; undisturbed peds – phys.
- Subsurface 35-45 cm, 3 pooled cores – chem; undisturbed peds – phys.


dripper
dripper
20 cm

If you have used soil tests, do you use them regularly?

A. No
B. Annually
C. Once every 3 years
D. Less frequently
E. Other



Outline of Presentation

1. The importance of soil quality/health
2. The development of a standardized set of indicators and benchmarking regions
3. What we have done and how to use the tests